1996 CAPE TOWN

7 October - 9 October 1996
The Lord Charles Hotel, Cape Town, South Africa

Paper 9600

Index of 1996 Conference Papers

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MONDAY 7 OCTOBER 1996

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Paper 9601

David Rayner

The use of Risk Management Practise in the safeguarding of safety of the privatised Railway Industry in Britain

CURRICULUM VITAE

David Rayner

David Rayner is Director, Safety & Standards, Railtrack PLC and a member of the Railtrack Board. A career railwayman, he joined British Rail in 1963 after graduating at Durham University and has worked widely across the rail network. Involved in the creation of railcards and national travel promotions, Mr Rayner was appointed Director, Passenger Marketing at British Rail Headquarters in 1981.

He became General Manager, Eastern region in 1985, and joined the British Rail Board in 1987. Following the serious accidents in that and the following year, he has led the overhaul of safety management practise throughout British Rail. Latterly he has been closely involved with HSE in devising new safety arrangements to support rail privatisation. He moved to the Board of Railtrack at its inception in April 1994.

THE USE OF RISK MANAGEMENT PRACTICE IN THE SAFEGUARDING OF SAFETY OF THE PRIVATISED RAILWAY INDUSTRY IN BRITAIN

DAVID RAYNER
Director, Safety and Standards
RAILTRACK PLC
UNITED KINGDOM

Most delegates to this Conference will be aware of the major restructuring and privatisation of the main line railways in Britain.

In a politically driven initiative - as part of a Government programme of major industry privatisations in pursuit of improved efficiency and customer service - the vertically integrated and unitary organisation of British Rail, state owned for almost 50 years, has been systematically broken up and either sold or prepared for sale. [VIEWFOIL]

The restructuring has been politically controversial, and the preservation of system safety - a hallmark of British Rail - has been one of the recurring themes of the political and media debate.

Opponents of privatisation have argued that without an integrated command organisation the delicate balances necessary to maintain a busy, but safe, network of rail services will be put at risk.

Proponents of privatisation argue that other risk industries are similarly complex, yet manage safety successfully through a network of different ownerships. Why should railways be any different?

How then is safety managed in this newly privatised, interlinking complex of 100 or more rail companies? What is the outlook for maintaining high safety performance?

The restructuring and privatisation of Britain's railways has been accompanied by significant and far reaching changes in the safety management regime of the industry and by changes in safety legislation. The changes represent the outcome of a collaborative effort between the Government, Health & Safety Executive (HSE) and railway management. The new regime is based on principles contributed by each of the parties. [VIEWFOIL]

- a risk based system of safety management developed by British Rail in the years following the major rail accident at Clapham Junction;

- a cascaded and interlocking "Safety Case" approach to the demonstration of safety management capability and competence, developed in the nuclear industry and subsequently in the off-shore oil and other risk industries and adapted for railways by HSE.

Following the serious train accident at Clapham Junction in 1988, a major overhaul of the BR Safety Management System was initiated. There was recognition that the heavily rules- orientated, functionally driven safety management system that has evolved over very many years was no longer appropriate in a Corporation whose strategic direction was fundamentally changing from a public service utility to a market driven conglomerate of rail businesses.

If the Corporation was to take on board the organisational restructuring necessary to deliver business leadership and promote innovation and change, then the Safety Management System itself must undergo root and branch reform - placing overall safety responsibility with the business decision makers and devolving specific safety responsibilities, on a risk allocated basis to the line management of the delivery organisations.

Based on the historic safety records - which for British Rail are long and detailed - safety performance targets for the Corporation overall were identified, and agreed with the then owner, Government. These explicit targets - [VIEWFOIL] based on risk tolerabilities - 10^{-5} p.a. for frequent travellers on the system, 10^{-4} for the out-door workforce, 10^{-6} for public - were used essentially as "hurdle rates", to use a financial analogy, against which the safety performance of the components of the Corporation would be measured and compared, and also, importantly, against which changes in the businesses - organisational, technical, operational, working practices, etc - could be appraised, using risk analysis (albeit crude and judgmental in many instances) to identify changes in safety risk. Where risks rose significantly as a result of the proposed change, then appropriate new or revised control or mitigation measures were to be put in place to return the risk to target levels, consistent with the overall risk targets, or the change was to be modified or abandoned.

Thus was a risk based concept of safety management introduced, capable of dealing rationally with innovation and change supportive of a business led system of management. It prompted, over the span of three or four years, a whole series of risk analysis templates and the compilation of a body of practice knowledge which reinforced managers confidence to move to the new basis of safety management. And it encouraged the development of a values system for safety, using the concepts of safety cost benefit analysis and the derivation of values of life, to create a framework of rational safety appraisal that would facilitate a responsible, albeit pragmatic, rationale for safety standards, safety investment and other safety decisions.

In this latter context, the Corporation realised that it could not stand still in safety performance terms. British society has rising expectations in rail safety, as in much else in the service supply area, and British safety law demands that, at any point in time, safety risks be controlled to be as low as reasonably practicable at any time.

There was acknowledgement that many of the changes and developments in the industry provided windows of opportunity to take reasonably practicable (i.e. economically justified) steps to improve safety. Thus the concept of continuous and affordable improvement in safety became accepted throughout the Corporation, prompting a positive, opportunistic outlook towards safety around investment and renewal projects and other business developments.

Much of the detail of this risk based system of rail safety management in Britain is known to many colleagues at this Conference and is written up and published as conference and seminar proceedings and in the railway press.

Suffice to say for the purposes of this address that the changes brought about a knowledge of risk management and a preparedness to apply it to the railway scene, which, being quantitative and numeric, engaged the intellectual interest of the business managers and gave them confidence to be innovative and dynamic in their business strategies whilst at the same time, achieving visibly improved safety performance in the industry. It is a matter of record that between 1990 and 1995 fatal accident outcomes, of passengers, public and staff, halved in number.[VIEWFOIL]

Leadership in safety, like leadership in quality and customer focus became the preserve of the business manager and no longer the functional specialist.

Concurrent with these rail industry developments, the HSE were devoting considerable attention to the adoption of more formalised safety management systems for large scale industrial enterprises where there was a diversity of risk exposures, and frequently a diversity of participating organisations.

The impetus for this work stemmed from another major accident, on the Piper Alpha oil rig, offshore in the North Sea. From that accident came a very thorough inquiry led by Lord Cullen, and a report [VIEWFOIL] which has proved to be a landmark in European safety management practice. Cullen identified the complex interaction of equipment, plant and operators on offshore oil rigs, which demanded a level of compliance with strict operational procedures and a sophistication of overall control that required an altogether more rigorous, measured and committed safety management system. Cullen proposed the preparation of a "safety case" for each rig, which would carefully analyse the hazards and risk exposures of every component of activity, would set out in such detail as was necessary the operational and control procedures, and would then demonstrate the management processes and competencies that would deliver a committed and credible safety management system to comply with the safety controls. The Safety Case would be prepared by the owner or operator of the rig and would be examined and formally accepted by the safety authority. The Safety Case would be a "living" document which would be amended and updated as change occurred and the safety management system adapted.

It has been the HSE's significant contribution to adapt the Cullen approach, as now widely employed in the oil and chemical industry, and elsewhere, to the fragmented rail industry. Their skill, in the view of the speaker, has been to recognise the relative maturity of technology in the railway, and to the extensive understanding of risks, and to so adapt the Safety Case approach to make it as practical and bureaucratically "light" as possible. [VIEWFOIL].

Thus has come together a system of safety management for railways based on risk management practice, but having a formality of expression, via the use of safety case practice, that enables responsibilities to be identified, control measures committed and organisational capability to deliver compliance and control set down, for overall assessment and formal acceptance, of safety assurance and as a basis for continuous monitoring, check and audit.

In the new structure, Railtrack as owner of the greater part of the mainline network and controller of train movement, is cast as Infrastructure Controller and directing mind in safety. [VIEWFOIL]

In this role, Railtrack submits to the UK Safety Authority, the Railway Inspectorate and has accepted, a Safety Case detailing not only how it will safely maintain the railway infrastructure and safely control train movement (via the signalling system), but also identifying how it will safely control the risks necessarily imported onto the infrastructure network by each of the 50 or so Train Operating Companies and other users.

Railtrack exercises these responsibilities by requiring each of the Train Operating Companies and other network users to themselves present a Railway Safety Case, demonstrating their understanding of the safety risks they generate, how they are to be controlled, and how the management arrangements for control will be exercised in close harmony with those of Railtrack and other operators.

In themselves importing risk into their own operations, through procured equipment and contracted services, the Train Operating Companies will also set down in their Safety Case how they will properly control those risks with their suppliers and contractors.

All the parties must demonstrate commitment to the network targets of acceptable safety performance, and to common safety standards of engineering, operations and competence, set down by Railtrack.

Thus an interlocking structure of accepted safety management systems, checked for consistency, compliant with common policies, principles and safety standards, provides some considerable confidence that, despite the fragmentation of the industry, and the divided ownership, and the expectation of major business, technical and attitudinal changes, safety can continue to be managed in an effective manner, and largely as an industry owned and managed responsibility, with the Government safety agency, acting in a regulatory rather than executive role.

I should add that Railtrack also adopts the same safety case approach to the contracting of our processes of infrastructure installation, maintenance and repair, requiring each major contractor to submit and have accepted a Contractor's Safety Case. [VIEWFOIL]

My colleagues, Matt Walter and Mike Siebert, in their presentations to this Conference, will explain in somewhat fuller detail how Railtrack sets safety standards for the network and how it manages the Safety Case arrangements for Train Operating Companies.

I want to devote the remaining minutes of this presentation to a consideration of the strengths and weaknesses of this innovative, and currently uniquely British approach to railway safety management, and to recount some of our experience of the process in the two and a half years since its inception.

In first looking at the strengths and weaknesses of the approach, the criteria of evaluation are not just that the regime must continue to delivery safety, but it seems to me, that it must be seen to delivery safety. In Britain today, as in other developed countries, there is a high and growing expectation of industry and commerce that its products and services will be safe, and that the systems it has in place to deliver safety, and the competence of the people involved are demonstrably rigorous and well managed.

Accidents, as we the specialists in safety know, will from time to time continue to happen, but society, whilst it can understand errors and flawed judgements in safety, is increasingly intolerant of incompetence and inappropriate process. [VIEWFOIL] Society also expects responsibility for error or failure to be identified, and, as necessary, for the due processes of the law - both criminal and civil - to play their part.

The great strengths of the new regime in Britain are its objective, and as far as possible, numerate approach, its openness and visibility, the prior acceptance principle, following close independent scrutiny, and its facility for objectively handling change and innovation.

By setting out to identify all significant risks, [VIEWPOIL] and by utilising methods of doing so from an extensive array of risk management diagnostic tools available today, then there is demonstration of managerial rigour at the core of the safety management system. Moreover, by submitting this analysis to the scrutiny of an independent acceptance body - Railtrack in the case of Train Operators, the HMRI for Railtrack - then further rigour is brought to the process.

The identification of individual managerial responsibility for control is another output from the analysis process, and drives the responsible party, aware of the risks and alert to the implications of failure, to put forward appropriate measures to manage and control those risks.

Moreover, since the whole process is on a measured risk basis, then the identification and design of effective controls can be undertaken in a systematic way, so that both the responsible party, and the safety case accepting party, can be satisfied the measures proposed to control risks as low as reasonably practicable - the test of fitness in British law.

Thereby, the business imperative of value for money is also satisfied.

Finally, by committing the risk analysis and resultant safety management system to paper, there are a further series of strengths from

- its availability as a basis for handling change, in a structured and objective way;

- its use as the basis for inspection and audit of compliance;

- to facilitate the systematic review of safety management system adequacy, in the light of the evolving record of safety performance monitoring

- its use, post accident, to focus on underlying causes of failure, and breakdown in managerial responsibilities and so sharpen recommendations for improvement.

What then do we see of the dis-benefits and downsides? [VIEWFOIL]

First, moving to a measured risk basis of safety decision making, brings the necessity for a more structured and inevitably more administratively heavy process of management. Risk assessments must be made and recorded. Control measures must be formally set down and promulgated. All involves additional administration and a management system to ensure that it is updated and dynamic.

Many of the control measures apply across the network. Thus the system demands a rigorous Standards regime, with the evaluation, iteration and application of the Standards as a significant activity in its own right. (Matt Walker will allude to this).

Our conclusions are that these extensions of the management and administrative process are a small price for the potential improvements in safety assurance.

But that requires one risk to be recognised and itself controlled. The risk of bureaucracy. This can have two insidious effects. The first is that, unless resolutely resisted, the bureaucracy of the system comes to govern the system itself - stifling change, lengthening timescales, creating cost, and ultimately encouraging aversion to safety risk itself.

Secondly to create a bureaucracy around an essentially pragmatic management technique - risk management - is itself to risk the middle ranks of practitioners - middle and junior managers, safety advisors, etc - believing in the absolutes of numbers. In Britain the railway has traditionally displayed a weakness here. Middle management has not had a good understanding for the context and perspective of figures. The "million and one pounds" syndrome I call it: a belief in spurious accuracy.

Risk analysis is essentially judgmental. The frequency of many risks is very low. Accident outcomes are usually random. To create through a bureaucratic framework a blind belief in the risk figurework will be to assume an integrity of the resultant decision making that is false and dangerous. Bureaucracy creates respectability in the eyes of those who create and use it. We know that risk management is itself a very useful development in safety management. But it requires the exercise of discretion and of challenge and of the very careful interpretation of figures in the support of decision making. It is at best an aid to managerial judgement.

So there are downsides to the move towards a risk based, formalised system of safety management for railways.

But our experience in Britain is that this system does provide a workable framework in which radical change may be made to the structure and ownership of the railway, where commercial and technological innovation may be introduced in the wake of new management thinking and new sources of funding, and where the management of safety may be brought into and integrated with the mainstream of business management and preserve the high and rising standard of system safety.

Let me be frank however: the change to the new safety management system is not without is growing pains. [VIEWFOIL]

After 100 years of an autocratic, handed down system of prescriptive safety measures, functionally driven and with origins frequently lost in history, the change in culture required of the new regime is considerable.

The requirement for the board or management team of each company - no less - to familiarise itself with the principles of risk management, and to apply them to its own activities is an onerous task. The identification of risk exposures, the realisation of accident vulnerability and the implications for personal and company responsibilities and liabilities is a salutary experience for most managements. The realisation that compliance with the Company's own owned and devised safety management system is a requirement of management, staff and contractors, and that the safety case, with control measures spelt out and management processes defined, is the basis for check and audit with irrefutable findings are all downstream recognitions that do not emerge immediately.

Railtrack has made its share of mistakes.[VIEWFOIL] There was insufficient consultation with the business directors and senior line managers in the construction of the safety case. As a result, the level of understanding and sense of ownership was not well developed and no great value was initially placed on compliance with its undertakings. Railtrack has been rightly taken to task by the HMRI over its failure to apply its own safety standards to its own contractors. Its lack of systematic checking and audit of its committed safety management arrangements has also been found wanting.

There have been emerging problems too in the application of risk based acceptance of technical innovation. The evaluation, for instance, of the impact of very low frequency electromagnetic interference generated by innovative new designs of traction motors on the varied stock of track circuits installed throughout the network has proved to be a very difficult risk issue to handle, and commissioning of some new rolling stock has been held up.

The use of risk analysis and cost benefit techniques to establish the reasonable practicability of network safety standards has also proved difficult and irksome to many functional experts.

All these (and many more transitional problems

But, throughout, the safety performance of the network has held up. [VIEWFOIL] 1995/96 saw the lowest level ever of fatal accidents. Serious injuries were down and time loss accidents fell. Seemingly declining trends in collisions, derailments, fires, signals passed at danger, have been established and are being maintained throughout the restructuring and privatisation process.

We remain confident that our new ways of managing safety are fit for purpose and fitted for the revitalisation of Britain's railways. [VIEWFOIL]

And, as safety practitioners, we are encouraged to persevere with perfecting the system in the knowledge that our railway is now plugged in to the mainstream of international industrial safety practice and will undoubtedly benefit, long term, from the developments and improvements that derive from exposure to the sustained quest for progressively higher levels of industrial safety performance.

David Rayner
Director, Safety & Standards
Railtrack PLC
3 September 1996

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Paper 9602

Mike Siebert

Railway Safety Case Procedures

CURRICULUM VITAE

M. L. A. Siebert

Graduated in 1969 with B.Sc. (Special) Degree in Chemistry awarded by London University.

- 6 years Production management experience in electronics, iron and steel processing (in Japan) and industrial chemicals.
- 8 years experience as a Specialist Inspector in the Health and Safety executive, specialising in fire and explosion hazard prevention.
- 5 years as Head of Safety in a major international food manufacturing group.
- Joined British Railways in mid-1990 in the new role as head of corporate safety audit.
- Appointed Director, Safety BR in February 1992.
- Transferred to Railtrack plc on its formation in April 1994 as Controller, Safety Assurance in the Safety and Standards Directorate.
- Spent one week with Spoornet in February 1994 to help develop safety case processes.

Responsibilities include:

- Managing Railtrack's own Railway Safety Case.
- Directing the scrutiny and acceptance of other operators' Railway Safety Cases.
- Audit, monitoring and reviewing conformance with Railway Safety Cases of other operators on Railtrack's controlled infrastructure.

Additional qualifications include:

- Chartered Chemist, Member of the Royal Society of Chemistry, Member of the Institution of Occupational Health and Safety
- Member of the International Institute of Risk and Safety Management

RAILWAY SAFETY CASE PROCESSES

Mike Siebert
Controller, Safety Assurance
Railtrack PLC

Introduction

The purpose of the Railway Safety Case (RSC) is to demonstrate that the train and station operators have the ability, commitment and resources to properly assess and effectively control risks to the health & safety of staff and the general public and to provide a comprehensive working document against which management (and the acceptor and safety regulator) can check that the accepted risk control measures and safety management systems have been properly put into place and continue to operate in the way in which they are intended.

The infrastructure controller must be assured that the activities of the train operator will not prevent him from discharging his legal obligations to operate safe infrastructure.

The purpose of this paper is to explain the 3 activities which form part of the Railway Safety Case process

- safety validation
- safety review
- safety assurance

and identify the improvements to be brought about to meet the requirements of Railtrack as infrastructure controller and the train and station operating companies.

Safety Validation

The first part of the process is the review and acceptance of the submitted document - "safety validation". This is undertaken by a team of specialists whose skills will reflect the proposed train operation.

They will satisfy themselves by review and study of the document, plus a face to face meeting with the operator, that the risks have been properly identified and assessed and that the control measures proposed will be effective. There may be significant negotiation in this process but crucially, it ends with agreement between the train operator and infrastructure controller as to the nature and size of the risks and the control measures required, especially when those control measures span organisational boundaries - "interface risks".

Since safety validation always takes place before the operation or change is implemented, it amounts to acceptance of a series of future commitments, albeit based on current performance. In our view, it is essential that this agreement is reached between the relevant parties and not imposed by some third party or independent regulator.

Safety Review

Once accepted, the safety case must be implemented, monitored and audited. The infrastructure controller must assure himself that the risks are being controlled as agreed. The Safety Review organisation carries out this role for S&SD. Essentially, they consult the Railtrack Zones and other parts of S&SD to build a picture of past performance and then prepare a remit for an audit. The Safety Audit Department of S&SD carry out the audit and the Review team will then seek an action plan from the train operator to remedy any non compliances and will normally meet the operator to agree the action plan and timescales. This plan will be taken into consideration when the next audit remit is prepared. The process also includes a review of the overall safety performance of the operator.

Safety Assurance

The third leg of the process is called safety assurance.

Both validation and review are "set piece" activities with clear remits and occurring at set times. We recognise a need for both formal and informal contact with operators between these set pieces, especially in a rapidly evolving railway. I have a senior manager who assists me in this activity and we act as a bridge between the operator and any part of S&SD (and indeed Railtrack as a whole) to ensure that issues are managed as they arise and are not allowed to fester and become the centre of major dispute. We will expect to meet each operator at least once, and often twice, each year. We also maintain contact with the Zones. Intelligence gained during this process is shared with the relevant Departments who may then wish to contact the operator to resolve the developing issue.

Process Outcomes

We have significant experience of this process now since we have accepted 53 RSCs since we started. We have also undertaken material and non material changes to most of these, many more than once. So, what are the emerging issues?

Firstly, the industry is changing rapidly, and this requires rapid response to requests for change. From the early beginnings, where we waited for the operator to submit his case for review, we have moved to a position whereby we invite the operator to approach us as soon as he has identified the change he wishes to make. We will then agree with him what are the key issues and work with him to resolve them so that his first submission fully addresses the issues. We have found that this significantly reduces the time taken to complete the validation. We are satisfied that we can do this without losing our independence from the operator in checking the document. Essentially, we are agreeing the nature and size of the risks and the control measures with the operator before the written submission rather than after it.

The emerging issues largely relate to risk assessment. The industry will develop and grow by change and innovation, not by stagnation in existing processes. We are determined that, provided the risk assessment is suitable and sufficient, we will accept the process even if the outcome is not known with any certainty, because the areas of uncertainty will have been identified and controls put in place to identify outcomes and manage them. What is "suitable and sufficient" will obviously depend on the nature of the change sought.

Material changes to a RSC require revalidation by the infrastructure controller. It will always be difficult to define exactly which changes are material and which are not. Clearly, many changes obviously fall into one camp or the other but there will always be a grey area. Our task is to limit the grey area to allow operators as much certainty as possible.

Similarly, our Review process is developing fast. In their first year of existence, operators receive 2 reviews and in subsequent years only one (unless severe deficiencies are identified). The audit and review moves from being intrusive and in-depth in early inspections to a later demonstration of good management by the operator. We are now moving to a single question audit of a RSC: "Please, Mr MD, show me how you satisfy yourself that you are complying with your RSC". Naturally, there are likely to be one or two subsidiary questions! Nevertheless, the operator should be able to demonstrate that his own monitoring, audit and review processes are adequate.

What have we found so far? Generally there is a willingness to comply, though some organisations have made better progress than others. The biggest problem has been that some RSCs have been written as statements of intent rather than statements of activity. This is being addressed by those operators as they have gained experience in day to day operations of trains and stations.

Conclusions

The overall effect of these processes has been positive towards safety. Indeed, since the first forms of safety case were introduced by April 1992 we have managed to halve the average fatality rates for staff and passengers from 24 and 13 respectively in the three years to 1991/92 to 13 and 5 respectively in the four years to 1995/96. We can never be complacent and accidents, such as the tragic collision at Watford, may still occur from time to time, but what we have all achieved is a clear focus on the risks and relevant controls and a continued will to manage as safely as possible.

RAILWAY SAFETY CASE PROCESSES

Mike Siebert

Controller, Safety Assurance

Railtrack PLC

PURPOSE

- Demonstrate ability, committment & resources to control risks
- Provide comprehensive working document

PROCESSES

- Safety Validation
- Safety Review
- Safety Assurance

SAFETY VALIDATION

- Agreement between Infrastructure Controller & Operator on
  - activity covered
  - nature & size of risks
  - control measures employed

SAFETY REVIEW

- Review of
  - safety performance
  - safety audit outcome
- Agreement of Action Plan

SAFETY ASSURANCE

- Formal & informal meetings
- Intelligence gathering
- Identifying & managing friction issues

EMERGING ISSUES

- Rapid change in industry
- "Suitable & sufficient" risk assessment
- Material change
- Self audit & review by operator

RESULTS

ACCIDENTAL FATALITIES

	Passengers	Staff
3 Years to 1991/92	24	13
4 Years to 1995/96	13	6

(Average per year)

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Paper 9603

Dr M. H. Walter

Railway Group Standards
Present and Future

Publisher
[illegible]

CURRICULUM VITAE

Dr M H Walter

After spending 11 years in engineering and safety consultancy, Matt Walter joined the British Rail Safety Directorate in the middle of 1993. As Head of Safety Validation, he was responsible for:

- Safety validating the disaggregation of British Rail into franchisable units and the formation of Railtrack, and
- The production of Railtrack's Railway Safety Case
- In April 1994, he transferred to Railtrack's Safety and Standards Directorate, where he:
- Developed and implemented the processes for assessment and acceptance of train and station operator's Railway Safety Cases, and
- He maintained and update Railtrack's Railway Safety Case, including the validation of material changes.

Currently, Matt heads up the Safety Standards department which is responsible for the development of new and revised Railway Group Standards.
These standards, which cover Operations and Engineering functions apply to railtrack and train station operators.

Define the high level control requirements that respond to Railway Group safety objectives and Railtrack's Railway Safety Case.

INTERNATIONAL RAILWAY SAFETY CONFERENCE

CAPE TOWN

7/8 OCTOBER 1996

RAILWAY GROUP STANDARDS - PRESENT AND FUTURE

Dr M H Walter
Controller, Safety Standards
Safety Standards Department
Railtrack PLC

Rail safety continues to be an important issue and also a personal issue to the many thousands of people who regularly use the railways. With the majority of the industry being in the private sector there is increased pressure for improving profitability and efficiency. There is general recognition that if the network is to flourish and traffic to grow then change, innovation, new equipment and new working methods need take place. Railway Group Standards have a key role in this drive for change since they provide the core of the risk control measures for maintaining safety.

This presentation provides a background on Group Standards, the changes made since Railtrack inherited responsibility for these Standards from BR, and the proposals for further review to finally align Railway Group Standards to the Safety Case regime.

Prior to the privatisation of British Rail and the "open access" of the railways, the Government set the scene for today's safety regime in a publication entitled "Ensuring Safety on Britain's Railways". It determined that prime responsibility for safety rests with the party in control of the activity, that operators must be accountable for those aspects for which they have control, and that the party in control of the system itself has a responsibility to impose conditions of access and to monitor what is going on in its system. "Ensuring Safety on Britain's Railways" also identified the particular part to be played in the new safety regime by the Infrastructure Controller, in this case Railtrack, which is in operational control of the infrastructure. It is established that the Infrastructure Controller must be assured that unacceptable risk will not be imported onto its system, but that this did not relieve other operators of their own safety responsibilities.

It is these principles which not only gave Railtrack, as an infrastructure controller, the justification to assess the Safety Cases of train or station operators before they commenced operation, but also the justification for it to require such operators to comply with Standards that are designed to achieve compatibility and safety of operation. These two requirements are brought together in the Railways (Safety Case) Regulations, 1994 which require an infrastructure controller's safety case to indicate what Standards the infrastructure controller and train and station operators will be required to follow.

In terms of organisation, it was, therefore, appropriate that the body which held responsibility for accepting the Safety Cases of train and station operators and auditing compliance of mandatory Safety Standards and setting Safety Policies and Plans should be part of Railtrack.

The body with this "Directing Mind for Safety" role is the Safety & Standards Directorate which operates independently of Railtrack Line. It is the Safety Standards Department within this Directorate which is responsible for the development and publication of Railway Group Standards.

Railway Group Standards are developed in accordance with processes and procedures which meet the requirements laid down in Railtrack's Network Licence and subsidiary Standards Code and Railtrack's Railway Safety Case.

The procedures are certified to ISO9001 and are built on the procedures developed by BR utilising Drafting Groups and Subject Committees. Additional developments to create more democratic arrangements have been introduced and are encapsulated in RGS GA/RT 6001 known as "the Change Procedures". The salient features are: the use of consultation with wide participation at the drafting stage; expertise with wide representation on Subject Committees; elections for membership of Subject Committees; flexible arrangements for Standards meetings; and a dispute resolution process.

As at 1 April 1996, the review of the portfolio of Standards inherited from BR was mostly completed. Those not suitable for retention as a Railway Group Standard are in the process of being withdrawn and placed in the public domain or being devolved into lower level Standards by the relevant parties of the Railway Group. This review has resulted in a portfolio of around 600 Standards which was one of the objectives to be attained by the initial review.

A further objective was to reduce the amount of prescription contained in the Standards by adopting a goal setting approach where this is sensible to do so. Goal setting Standards enables the compliers to use commercial initiative to determine their own cost-effective methods of achieving the particular performance required. This objective was only partially achieved and is now the key driving force behind our current reforms and is essential if the benefits of privatisation are going to be delivered.

The challenge now faced with Railway Group Standards is the systematic justification of almost all of the 600 current Standards in the light of over 3 years practical experience of the new safety regime and the emerging needs for change by the end-users.

Such changes inevitably pose risks but the new safety regime of a cascaded Safety Case based system of safety management is already demonstrating its ability to handle change and the understanding and control of its safety implications. The Railway (Safety Case) Regulations provides for legally "backed" risk based safety management which puts emphasis on the prior accreditation of good safety arrangements before a company starts to operate or implements material changes, and then demands compliance with the management processes to which the company has committed.

The concept of "reasonable practicability" embedded in the UK Health & Safety legislation is now an important part of safety decision making process. In essence providing the risks an operation fall within defined tolerability limits for populations of people exposed to those risks, then the activities should be managed in such a way as to keep the safety risks "as low as reasonably practicable". Thus ALARP is a means of pragmatic decision making that recognises that the extent to which risk controls, or safety measures, need to have careful regard to the benefits generated to users of the activity and to the financial viability of the operator.

Safety evaluation, using risk analysis, target risk levels, willingness-to-pay values of preventing injury and fatality, and cost benefit analysis, from which can be determined objective safety measures for new or changed activities justified to meet "ALARP" requirements is to be adopted as an integral part of setting Standards and their justification.

The portfolio of Railway Group Standards are now in a phase of further rationalisation such that over the next couple of years Railway Group Standards will be aligned to the principle that they should define safety performance where it is sensible to do so and to deliver that safety performance consistent with ALARP and, in addition, that the ongoing review of Railway Group Standards and programmes for auditing compliance with Railway Group Standards shall be based on safety importance. These present a major challenge and has already required a fundamental review of the safety regime, the roles and responsibilities of the key "players" etc. etc. to determine compatibility between Safety Cases, Railway Group Safety Plan and Railway Group Standards.

One outcome of this review is a proposal for the scope of the Railway Group to be redefined. The new definition restricts membership to those who have "prime" responsibility for safety on Railtrack's controlled infrastructure – Railtrack which is responsible for the infrastructure itself and the provision of train paths and those responsible for the operation of trains and stations. This is consistent with the requirements of the Railways (Safety Case) Regulations and the cascade of safety arrangements i.e. Railtrack has legal power of control of Railway Safety Case holders but no legal power to direct other parties for example contractors to a Train Operator.

A second outcome concerns the "scope" of Railway Group Standards which is proposed to be consistent with the limits of Railtrack's health and safety responsibilities as "Infrastructure Controller". Therefore, the scope of Railway Group Standards will now cover only those activities which fall within the scope of Railtrack's, and each individual operator's, Railway Safety Case.

Railway Group Standards are legally mandated through the Railway Safety Case cascade and are thus confined to the safety of:

- train movements;
- station operations to the extent that they affect safe train operations or the safety of passengers using the station; and,
- [illegible] interfacing work on or about the line,

on Railtrack Controlled infrastructure.

These "redefinitions" have significant impact both for those still within the Railway Group and also to those no longer members. Of benefit to all are that safety responsibilities through the "cascade" are now more simple to understand, and clarity has been gained on defining those activities which are within the scope of Railway Group Standards. Many of the previous "grey areas" no longer exist.

Since July all new or revised Railway Group Standards require justification for their "prescriptiveness" and also require a "Safety Justification" at the Terms of Reference stage. This is very much a "breaking of new ground" and pilot studies are being undertaken to establish "good practice" and provide examples for inclusion in a Guidance Document.

Work is also ongoing to establish the relative safety importance of each Standard and its relationship with each of the Railway Group Safety Objectives to ultimately determine the effectiveness of the controls it delivers. In many cases a Standard actually addresses more than one hazard and more than one Safety objective, and can apply to different parties. Again various approaches are being taken as pilot studies to determine the most appropriate methodology for judging efficacy and also outcomes of change. Results from these pilot studies will be presented at the conference.

In addition to the review of the content and applicability of Railway Group Standards, the Safety Standards Department has developed a new IT system to support the management of Standards documentation.

Previously document control, project planning, managing the budget and resource allocation were all undertaken on disparate systems, some of which were not owned or managed by Safety Standards Department. This made it very difficult to control the process, and incurred unnecessary costs in the additional administration required to manage the business processes.

The system has been designed around the ISO9001 accredited processes for Standards development, but offers all the functionality necessary to support the work of the Department:

This has been achieved by the use of novel techniques to integrate commercially available off the shelf applications to exploit the benefits of a powerful relational database whilst minimising the cost of the investment in comparison to developing a bespoke system. The use of widely used "front end" applications minimises the need for user retraining.

The direct cost benefits arising from the modern IT support make this a worthwhile investment on financial grounds. But the project will deliver many other tangible benefits including enhanced functionality that was not available with the older systems.

The availability of this modern IT system to support the business will engineer a cultural change in Safety Standards Department and offer the flexibility of approach to its work that will be required in the future. It also enables Information and Standards to be made available in a variety of media such as the Internet and CD-ROM.

Safety Standards Department is acutely aware of the needs of the Railway Group and the challenges these pose. Implementation of the above changes will assist in meeting those needs.

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Paper 9604

Francois Van Eeden

A Public Health Approach to Rail Related Injury Control

CURRICULUM VITAE

Francois Van Eeden

Francois Van Eeden completed his matric in 1973 and joined the South African National Defence Force (SANDF), where he was trained as an Artillery officer. He completed several conventional and unconventional military training courses, the last being Staff Officers training at the South African Army College in 1989.
During this military career, he also obtained his Military Management Certificate (a special three year study for military officers presented by the University of South Africa - UNISA), and is currently busy with a B Comm degree (Risk Management) through UNISA.

Francois joined the South African Rail Commuter Corporation (SARCC) in 1992 after resigning from the SANDF as Lieutenant-Colonel (Staff Officer Operations), seconded to Metrorail Corporate Office as Senior Manager, Risk Management.

A PUBLIC HEALTH APPROACH TO RAIL RELATED INJURY CONTROL

(BY FRANCOIS VAN EEDEN &
ANDRé HARRISON)

RISK MANAGEMENT IN PRACTICE

7 SEPTEMBER 1996

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RISK MANAGEMENT IN PRACTICE
A PUBLIC HEALTH APPROACH TO RAIL RELATED INJURY CONTROL

1 INTRODUCTION

Although public and private transport-related injuries are major causes of death and disability, the relationship between transportation and public health in South Africa has received little attention. Rail travel typifies this situation, compounded by socio-economic deprivation and an alarming increase in a climate of violent related crime (1,3).

Apartheid land policy in the past created vast distances between residential areas and places of employment. Housing developments on the urban periphery resulted in rail transportation becoming the vital link between townships and city centres. Railway lines were soon bordered by informal settlements, and yet commuter and pedestrian traffic control was neglected. (Slides of informal settlements at (1) Pienaarspoort - Pretoria Region, (2) Tembisa – WITS Region, (3) Kwa-Mnyandu – Durban Region and (4) Khayelitsha - Cape Region). The situation was exacerbated by the increased volumes of commuters using the township lines, and the climate of resistance against the Government in the 1980's was associated with increasing train surfing and fare evasion (1,3). Even High-Tech measures to curb fare evasion, posed an unacceptable high risk to injury (Slide 5 - Retief Region to prevent fare evaders from escaping or running away from Stations without tickets), and was abandoned owing to cost and risk of injury (2,3). The horrifying result of fare evasion and measures to curb fare evasion on Tembisa Station is also still lying fresh in our memories (3,5).

The World Bank Recognises a positive relationship between GDP growth and infrastructural investment in developing countries. Efficient transportation is imperative if economic growth is to be sustained. One of the first infrastructural needs to be recognised is the provision of an efficient and affordable transport system. Until recently, there has been a paucity of research into the problem of railway commuter injury, and its effects on the economy, community and individuals still remains un-quantified. A holistic approach to rail related injury control is therefore needed (1,3).

This presentation is based on the first technical report by the Community Health Research Group of the Medical Research Council, ISBN 1 874826 39 0. It gives an overview of the Public Health Approach to meet the challenge of rail commuter safety in South Africa.

2 WHY THE PUBLIC HEALTH APPROACH ? (BACKGROUND)

2.1 Project Background and Defining Public Health Approach to Injury Control

Railway injury was identified as an area of priority research by the Medical Research Council (MRC)'s National Trauma Research Programme as far back as 1992, as a result of their data showing a disproportionately high incidence of rail commuter injury in the Western Cape. A pilot study was initiated in 1995 by the MRC and the Departments of Forensic Medicine and Community Health of the University of Cape Town, with the intention of identifying areas of future focus and exploring a framework for an integrated intervention based injury control strategy. This study was done with full support and co-operation of Cape Metrorail and constituted a retrospective analysis of secondary data sources from a study population of more than 500 000 daily commuters. Data was collected from three secondary sources:

- Cape Metrorail,
- Cape Western Cape mortuaries and
- Groote Schuur Hospital

The Public Health approach to injury control could be defined as the treatment of injury as a disease, with associated vectors and risk factors, providing a methodology for interventions. This demands a scientific approach to injury prevention, using a broad array of resources in medicine, engineering, social services and education.

This PILOT project will be finalised by April 1997 and it is hoped that the project will culminate in the implementation of a sustainable National Rail Injury Reduction Strategy for Metrorail.

2.2 <u>The Status of Injury Control</u>

Injury control has only recently been identified as a public health priority. In the United States, National Health Objectives include the reduction of injuries and violence as a disease prevention and health promotion activity (Brown et al., 1990). There is now increasing concern about the rate of injury as a contributor to the Global Burden of Disease (GBD). As disease that affects the young, injury is the leading killer of South Africans below the age of 44 (Bradshaw et al., 1992). Trauma was responsible for approximately 12% of all mortality in the Western Cape and railway fatalities accounted for 9% of all trauma deaths (Matzopoulos, 1994). Reduction in mortality rates will not be achieved through hospital based curative services, but through basic health promotion and disease prevention which includes injury control (Bradshaw et al., 1992). Sub-Saharan Africa with 10% of the worlds population, accounted for 30% of GBD in 1990. The success in the control of infectious disease has brought injury to the fore as a public health problem.

2.3 <u>Metrorail's effect on Public Health</u>

A study of orthopaedic morbidity at Groote Schuur Hospital revealed that more than half of all train injuries (56%) affect those under the age of 30, with a high cost of disability and rehabilitation (Singer and Anderson, 1988). An unpublished report by the National Research Programme (NTRP) of the MRC, highlighted the severity of rail related incidents with more than 50% of incidents resulting in death (Maglo Peden NTRP). A mortality surveillance study of Cape Town city mortuaries revealed 305 rail related fatalities in 1993 (Matzopoulos, 1994). The seriousness of the situation cannot be over emphasised considering the latest statistics (July 1996) relating to injuries and deaths

CAUSE	INJURED	KILLED
Accident (Third Party)	0	1
Assault on stations (Crime)	24	0
Assault on trains (Crime)	4	0
Prevention of fare evasion (Tembisa disaster)	64	[illegible]
Fell between train and platform	1	0
Fell out of trains/dropped and fell off or disembarked or embarked whilst the train was still moving	22	0
Injured on stations	5	0
Injured on trains	2	0
Level crossing accident	1	0
Metro personnel injured	13	0
Metro personnel killed	0	1
Murder	0	1
Rape on trains/stations	4	0
Robbery on stations	5	0
Robbery on trains	14	0
Security personnel killed/injured	4	2
Shooting incidents	2	1
Stabbing on stations	4	0
Stabbing on trains	5	0
Stone throwing	3	0
Struck by train	10	19
Thrown off trains	1	3
TOTAL	[illegible]	44

Although crime plays a very prominent role in rail related deaths and injuries, most deaths are related to people crossing the lines unlawfully (Wessels, 1991; Bourne and Mnimazi, 1993; De Waal et al., 1994) and the same trend is prevailing.

The Government's Reconstruction and Development Programme (RDP) focuses on the need to "redress the harmful effects of apartheid, encourage and develop delivery systems and practices in line with international norms and standards, promote efficient and compassionate delivery of services and ensure respect for human rights and accountability to users". It is clear that this imposes on transport providers a duty to ensure the safety of commuters, and highlights the need for a comprehensive commuter safety strategy.

2.4 "A Rights Culture for South Africa"

Commuter safety has profound legal implications with the possibility of litigation and claims for damages by injured parties. There has been an increase in the use of epidemiological evidence in the United States in Tort Litigation (Christoffel and Teret, 1991), in which a plaintiff is required to pay compensation for civil or non-commercial wrongs caused to others. The South African equivalent of Tort Law is the Law of Delict, which deals with issues other than acts of unlawful conduct, such as criminal conduct and breaches of contract. Delict applies to a breach of duty as imposed by law. In the case of railway injuries, the law would impose upon Metrorail the duty to take all reasonable practicable steps to ensure passenger safety. The emergence of a rights culture in South Africa, will empower both the commuter and those who live in the close proximity of the railway lines to demand safe travel in a secure environment. Commuter safety is congruent with the goal of operational safety (1.3).

3. THE PUBLIC HEALTH APPROACH TO INJURY CONTROL

This approach provides a framework for addressing the prevention and control of injury. The causes and risk factors associated with injury may not always be as controllable or susceptible to intervention as those of a "normal" disease. The risk factors are diverse, and include the exposure of people to unprotected railway lines and unsupervised stations, risk taking, inadequate communication channels and warning systems, some old and unsafe carriages and criminal activity. The causes of injury can often not be addressed directly as they are brought about by more deep-rooted social issues such as poverty, alcoholism and violence and infrastructural decay owing to unstructured urbanisation and overcrowding prevalent in the metropoles.

3.1 Four Phases of Prevention and Control Implementation

The four phases proposed by the MRC are:

- Define the problem (Data collection and surveillance). These four phases will shortly be complimented by a very comprehensive Computer Assisted Risk Management System, currently under development by Transnet Group Risk Management, including modules such as Incident Reporting and Investigation (containing SCAT analysis Systematic Causational Analysis Techniques), Task Observation and Audits.

- Identify causes (Risk factor identification). This process is supported by the Metrorail Internal Risk Management Process and Procedures (A simplified process to support line management in the identification of risks and development of interventions to reduce, transfer, terminate or tolerate the risks. See Annexure A).

- Develop and test Interventions (Evaluation and research)

- Implement Interventions and Measure Prevention Effectiveness (Community intervention and demonstration programmes, training and public awareness)

Owing to various factors, mainly related to funding, there have been some set backs to the programme and intended interventions to minimise the risk of injury to rail commuters. We will however persist in the effort to find sustainable solutions in this regard.

4 CONCLUSION

Against the background of recent studies to investigate the viability of concessioning suburban rail transport in South Africa, the time has come to depart from the unsafe practices of the past and focus on new sustainable strategies to prevent and control rail related injuries in South Africa. We are no longer isolated from the rest of the world. There can be no compromise on the value of life. We need to bench-mark ourselves against international standards and invest in the safe rail commuting future of our children and the future of rail business in South Africa. We believe we are on the right track by adopting a public health approach to commuter safety.

The MRC project team consisted of :

- Dr Lee Lerer, MBChB, DForMed, BSc(Hons), MMed
- Richard Matzopoulos, BBusSci (Co-Principal Researcher, Community Health Research Group, Medical Research Council)
- David Bourne, BSc, BPhil, MSc
- Dr Rosette Phillips, MBChB, Junior Researcher (Capacity Building)
- Johannes Letebo Bopape, Junior Researcher (Capacity Building)

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Henrick Block

Safety Regulation and their Application

CURRICULM VITAE

Henrick Block

Henrick Block graduated from Tibble Gymnasium, Täby in 1972 with a General Science degree.

1973 - 79	Traffic Control and General Railway Administration Roslagsbanan Commuter Railway, Stockholm
1979 - 82	Traffic Control Swedish State Railways, Stockholm
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1988 - 90	Manager Traffic Quality Eastern Traffic Region Swedish State Railways, Stockholm
1990 - 94	Director Eastern Traffic Region Swedish State Railways, Stockholm
1993 - 94	Director Department of Traffic Control Swedish State Railways, Stockholm
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Safety Regulations and their Application: Developing Rules that Interact with the System

by

Henrik Block- SJ
Swedish State Railways

Synopsis

Traditionally, safety regulations in the railway sector have been written from a very rigid perspective. A consequence of this was that in many cases very little focus was placed on whether a rule was practical, i.e. whether it was reasonable to expect that it was indeed followed. This may perhaps have been acceptable in the past when railways were less complicated systems than today. However, as an organisation develops towards a more complex structure, the need to establish a well balanced interaction between safety regulations and the system becomes more evident. This paper describes some considerations that an author of safety regulations is faced with in a modern railway system, and gives some examples from the experiences made in Sweden.

1. Introduction

How can we establish a balance between on the one hand regulations, and on the other hand the general level of education and technology in order to maintain and improve the safety level of the railway in the future? What is actually the role of safety regulations in a modern railway system? These are some of the questions that we, as safety managers, have to ask ourselves.

For rather obvious reasons, the ideas presented are mainly based on experience from the Swedish State Railways. They may therefore not be relevant in every detail for another country with a different structure of society. However, despite these differences, railways have many problems in common. The paper has therefore been written with the aim of sharing some experiences that hopefully can be applied to a wide range of situations.

2. Historical Background

The railways, at least in Europe, were in most cases built by principals from the military defence in the nineteenth century. Traditionally, safety was therefore simply a matter of telling the employees "what to do". From the beginning there were just a few rules specifically related with safety e.g. most of the contents of the first Swedish rule book for railway staff are concerned with personal conduct!

However, accidents did occur, and as a result the authors of the safety regulations put in more and more detailed rules of how to handle different situations. They tried to cover every possible situation, so that the staff could find out exactly "what to do" in every conceivable situation. This principle of "telling the staff what to do" also served the purpose of relieving the railway company of most of the responsibility when an accident occurred.

Various technical systems for handling matters of safety were gradually introduced. The main reason for investing in these new, expensive systems was of course that the railways wanted to increase their total productivity, e.g. the line capacity and the maximum speed. These new systems in many cases entailed new solutions and new safety principles. Rules on how to handle this equipment, and even more what to do when the equipment failed, were therefore introduced. However, at the same time and irrespective of this migration towards a more technology based safety system, the complexity of the regulations had increased. This development has prevailed for some 150 years, and we have now reached a level when the old fashioned "cookbook" methods can no longer be expected to cover every situation. The complexity would in this case be of a magnitude where it wouldn't be reasonable to expect the employee to be fully updated on each individual rule.

Meanwhile the society, including peoples way of thinking and acting, has developed. The general level of education has increased dramatically. The way upon which we look at rules and regulations has changed. From the very start, children of today are taught to *question*. They no longer simply accept a statement, they want to know *why*. This attitude has of course led to considerable changes in the way we have as grown-ups. At least you want an explanation *why* you are expected to do something in a specific way. For an independent person of today, who is used to be entrusted with making own decisions, the "cook-book" principle would seem very difficult to accept. Such a discrepancy between the safety rules and the general attitude of the staff therefore entails considerable safety risks. The result may well be that a rule is ignored, simply because a person is convinced that he or she can handle the situation in a "better" way by merely using "common sense".

Traditionally, society has very much focused the responsibility on the employee. In the recent years however, the focus has been turned much more on to the employer. If it can be questioned whether it is reasonable to expect that the rules are indeed followed, then it can also be questioned whether it is reasonable to write such rules. This means that the railway can no longer transfer the responsibility to the employee by just writing detailed (and complex) rules.

3. Theory

In a situation as described, it is relevant to initiate a dialogue on how to preserve and improve safety in the future. We have to be prepared to adapt our philosophy to the inevitable changes that are taking place, and which no doubt will continue to affect the way in which we operate our railways.

Maybe the rules and regulations of today are too detailed ? If the staff can be given a training more focused on "understanding the system", then perhaps we can simplify the system and move away from the principle of "one rule for each situation". Could it be that staff with a better training and understanding of the "railway process" can achieve a higher safety standard with less detailed rules ? Is it perhaps time to look at rules and regulations from a new perspective ?

In very broad terms, safety is the result of everyone involved with safety matters handling his or her tasks in a competent way. This applies at all levels, from the bottom layer to the head of the organisation. Competence is the key-word.

Competence includes:

- Knowledge - that you understand a specific matter from a theoretical point of view.
- Knowhow - that you have become skilled in a task and understand your role in the system.
- Motivation - that you really want to do your part to the best of your ability.

Competence is created when well motivated people are given relevant, professional and well balanced training.

To be really competent, the staff has to understand how the system - technology as well as organisation - works. They have to understand why and in which way the technical systems can fail, the risks associated with such cases of irregularity, and how to handle the situation then. You can facilitate this understanding of the system by simplifying the technical installations and making them as user-friendly as possible.

Experience shows that a higher level of education and training, combined with a wider responsibility, will result in staff that will take a greater interest in their jobs. Not only will this result in a safer railway, but we will also get more active personnel, taking responsibility for their own situation and, in the longer term, for the railway organisation as a whole. The more people know about the general principles that govern the operation of their railway, the higher the probability that they will make the right decision, even in cases under heavy stress. It is also quite obvious that someone who understands not only the rule, but also the principles, is more likely to react to errors and/or potential safety hazards, thus giving a better protection against hidden faults or incorrect actions by other staff.

There is definitely an increasing number of people involved with railway safety in Sweden who would support the idea that the future must be based on simpler rules and a higher understanding of training.

4. Proposed Solution

At first we have to be prepared to accept that it will take several years to make any significant changes. It is not just a question of writing new rules; it is a question of attitude. It is therefore probably right to say that it is a continuous process without a definite end.

Training:

It is necessary to start with the training. Simplifying the rules without having prepared the staff for the change could be a very dangerous experiment indeed.

The ultimate goal of the training is to give the staff the know-how about:

- how the system works (technology as well as operation)
- how to analyse a situation
- how to manage situations when faults occur in the system.

The purpose of training is to give the employee the means by which he can take responsibility for his job, and by doing so also install a considerable portion of self-confidence.

In Sweden, we have a good start in our culture. Some of the staff e.g. the conductors, are already used to taking responsibility for passenger services. In the last decade, they have been given a greater freedom to act in the different situations that occur. Another example is the traffic-controllers, who are used to taking decisions and to accepting the responsibility all the time. The experience clearly indicates that with a portion of freedom to manoeuvre, people will also take on more responsibility.

Selecting personnel:

The railway needs people with great interest in their jobs and a high capacity for thinking and making decisions. The selection process is therefore of great importance. However, the first requirement for a successful selection process is that the demand is greater than the need. In other words, we have to establish a situation where working for the railways is considered as something desirable: not only as a secure position with a government controlled entity, but something interesting with a high status level.

The Swedish State Railways have become much more popular over the last ten years, with the introduction of our new high speed tilting train services. Considerable funds have also been made available to the National Railway Administration (Banverket) for track renewal and upgrades to the railway network. A similar pattern has been followed for other parts of the infrastructure. One example, is the stations, where we can now see the results of a major modernisation program. Of course all these different aspects have given a much more favourable picture of the railways and their role in society. In this respect, the situation must therefore be considered satisfactory.

Other factors related to training include the use of modern systems for selecting people with the right capabilities. This is of course rather basic and is used extensively by many railways. Even so, it is important to carefully monitor the progress of the students, in order to secure that, at the end of the training period, they meet the requirements and are capable of performing their functions in the system.

Regulations:

Considering safety as a matter of competence, the objective of the safety regulations is then to provide the staff with a framework within which they are allowed to act in order to handle a situation so that incidents and/or accidents do not occur. Regulations that do not fill these basic requirements have very little, if any, justification.

This means that it will be necessary to develop a new set of rules along more "frame-work" orientated principles i.e. to provide our staff with a limited base of comparatively simple rules, but not necessarily attempt to regulate every detail of every possible situation the author could think of at the time of writing. This must then be followed by a training program focusing on principles and guide-lines for the odd situations that occur very seldom.

One way of developing the regulations into a modern rule-book, is to start with targeting the regulations in one specific field. A considerable amount of work must then be used to create guide-lines. Before the new regulations are installed, the staff must be given specific tuition in the areas concerned.

In this process, it may well be that in some cases we have to move the responsibility from one category of staff to another. One example is the procedure for passing a signal at danger. Pending the circumstances, this can in the current system be done in several ways. In some cases the driver is allowed to take the decision himself, whereas in other cases he or she has to revert to traffic control following strictly formalised procedures. Perhaps the solution to the problem is to simplify the rule so that the driver always call traffic control to receive detailed instructions. This would be a reasonable way of handling the matter as the traffic controllers already from their basic training have a very high degree of understanding of the signalling system and potential hazards.

Once the first step has been completed, the process can then continue with other areas. It is a step-by-step process. However, it is of course very important that each of these steps is carefully evaluated before the next step is take. It is therefore necessary to monitor the whole process such that experience accumulated can be used in the subsequent stages.

Technology:

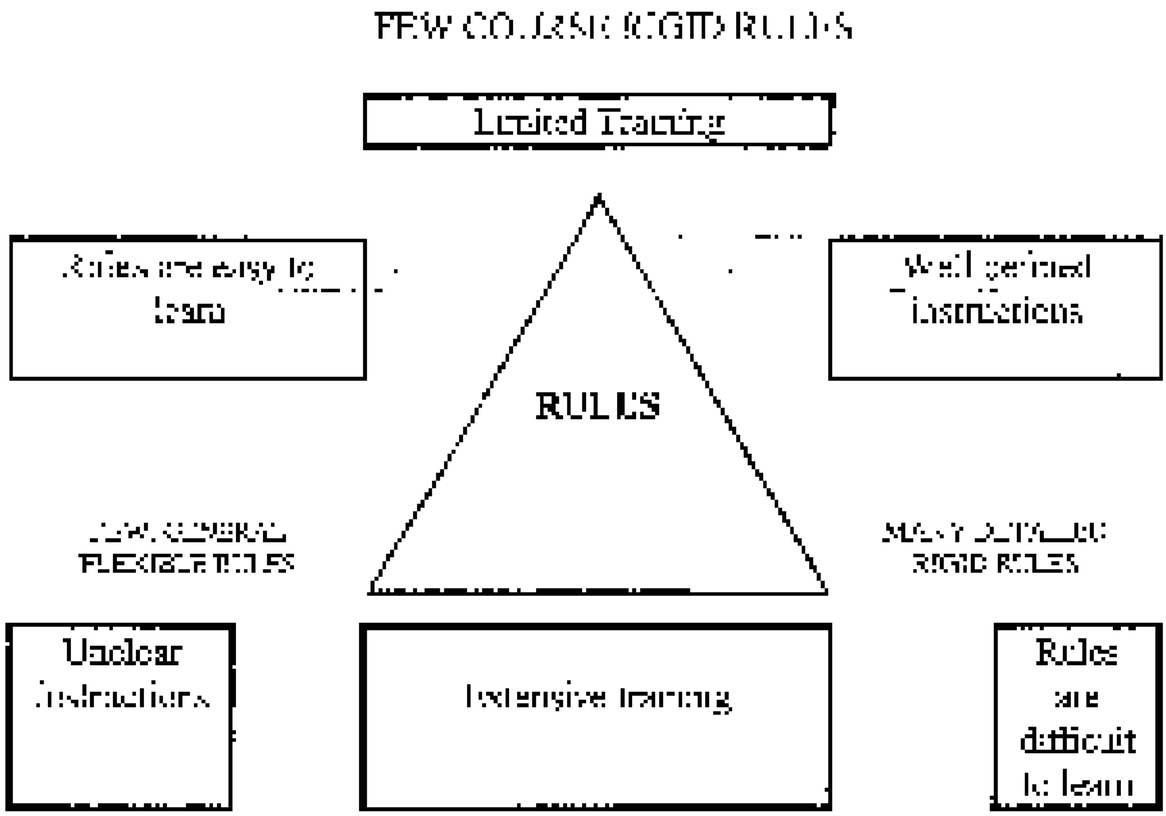
Everyone would no doubt agree that the technical solutions we employ must be safe. However, no system or device is inherently safe: it is "safe" only if it is handled within the limitations it was designed for. Some of these limitations are simple to quantify, e.g. temperature range etc. Other limitations are related with the actual operation of the system, and are therefore much more complex to specify. The greater degree of complexity, the greater is the need for making the systems user-friendly and standardised. Standardisation is in itself a simplification in that it reduces the number of alternatives, and thereby the amount of information to be acquired and remembered by the staff.

Another very important factor is that the systems we use must be well adapted for the tasks they are intended to perform. This may seem quite unnecessary to point out, but examples of cases where this is not true are not uncommon. It goes without saying that such discrepancies between technology and functionality lead to frustration and may result in non-standard "home-made" procedures, "short-cuts" or other safety problems.

5. Conclusion

Many railway systems, including that of the Swedish State Railways, have now reached such levels of complexity that it is getting increasingly difficult to maintain a system based on "detailed instructions for every conceivable situation". Meanwhile, the general level of education has increased, so that people nowadays are prepared to, and indeed capable of, taking much greater responsibility for their own actions. These two factors mean that the old-styled safety regulations - the instruction book, must be questioned.

In a modern railway, the safety philosophy must be adaptable to the users. We believe that this means to provide a good training based on "frame-work regulations", including guide-lines for odd situations, and selecting the best qualified people for each task. This is the key to establishing the competence needed for maintaining and improving the level of safety. With well motivated employees, given a defined amount of freedom to think and decide for themselves how to manage the situation, the railway paves the way for a better and safer future in a time of change.


FEW COARSE RIGID RULES
Limited Training
Rules are easy to learn
Well defined instructions
RULES
FEW GENERAL FLEXIBLE RULES
MANY DETAILED RIGID RULES
Unclear instructions
Extensive training
Rules are difficult to learn

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Paper 9606

Charles Erasmus

Management of risk and procedures to be followed after an accident/incident occurs

CURRICULUM VITAE

Charles Erasmus

Senior Manager (Train services), Metrorail

Charles Erasmus was born in Johannesburg and finished his school and university studies in 1973. He started his career in the then South African Railways and Harbours in the Operating Department. He worked in several sub-departments in operations, and in 1989 he was appointed as Deputy Director (Operating) in Cape Town.

In 1990 he resigned from Spoornet when he received an offer from the South African Rail Commuter Corporation as the Operating Manager. In January 1994 he was seconded back to Spoornet in the Metrorail division as Senior Manager (Train Services) responsible for the Operating function in Metrorail.

INTERNATIONAL RAILWAY

SAFETY CONFERENCE

SOMERSET - WEST

7-9 OCTOBER 1996

CATEGORY	:	Train Operations
PAPER	:	Management of the risks and procedures to be followed after an accident/incident occurs
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Contents

1. **Background**

Since the establishment of a Metrorail Division in Spoornet on 1 January 1994 the question arose as to the procedures that must be followed after an accident/incident occurs. All Rail Operators in the Republic of South Africa are subjected to the Occupational Health and Safety Act (Act 85 of 1993). The emphasis of this Act lies on the responsibility of the employer to ensure the health and safety of his employees as far as it is reasonably possible. A set of regulations for Railway Operators was drafted and promulgated compelling all Railway Operators to have safety procedures in place. To comply with legislation, the current procedures during a major accident/incident were formalised.

2. Introduction

Historically every accident was investigated and a formal accident report was compiled which contained conclusions and recommendations regarding corrective measures.

After the Mamelodi train accident in March 1994, a major change in the approach of handling accidents/incidents came into practice. External stakeholders such as political and community groupings became involved in the following process and as a result Spoornet and the asset owner (the South African Rail Commuter Corporation, SARCC) designed the management process that occurs after an incident has taken place. The insurers of the SARCC's assets have specific requirements as to how accidents/incidents should be handled in as far as it involves claims and other insurance related matters. Each incident needs to be treated within the ambit of a general framework, but on an individual ad hoc basis. There is a fine balance between the absolute necessity of the company to investigate an accident, ascertain what has transpired and decide what remedial steps are necessary, the element and desirability for transparency on the one hand and the necessity to keep one's affairs confidential and protect the rights and interests of Transnet/ Spoornet/ Metrorail/ SARCC and their underwriters on the other.

3. Tribunal **and other Actions by Chief Executive Officer**

The Chief Executive Officer or the Regional/Metro Manager depending on the seriousness of the incident/accident appoints a Tribunal. The functions of the Tribunal will be to seek legal advice regarding the Company and its employees position. Furthermore the tribunal co-ordinates and manages the process in an advisory capacity and liaises with the relevant Stakeholders i.e. Parliamentarians and community leaders. The Tribunal will be formed by all the Line Functionaries and/or Support Functions i.e. Risk Management, Legal Services, Human Resources and/or Loss Adjusters.

Depending on the extent of the accident/incident or likely consequences thereof, the Chief Executive of Spoornet and/or Metrorail or Regional and/or Metro Manager will appoint an Investigation Team or Board of Inquiry, to obtain legal advice for the company at an early stage. The internal legal advisor of Transnet/Spoornet/Metro is to be involved and he/she must decide to what extent it is necessary to involve the company's attorneys.

On receipt of the report from the Investigation Team the Chief Executive or Regional/Metro Manager will arrange for a brief to:

3.1 External attorneys.
3.2 Department of Labour
3.3 The Controlling Officers of employees suspected of having contravened Company Rules or if an instituting of the disciplinary steps is desired.
3.4 Line functions in respect of remedial action required in regard to maintenance or operational practices.

4. <u>Investigation Teams</u>

4.1 Attention is directed to the following extract from recent legal comments:

4.2 "The leader of the Investigation Team/Chairman of the Board must consult with the Legal member of this team or with the Legal Advisor to reach consensus on the information required by Insurance Brokers, Underwriters and the Company's Attorneys and thereafter inform the Site Co-ordinator of:

4.2.1 the information to be accumulated.

4.2.2 employees to be assigned to investigate specific aspects and/or to examine Rolling Stock, survey the rail features, etc.

4.2.3 photographs and videos that may/must be taken

4.2.4 whether photographs and videos in particular are to be legally privileged.

4.2.5 the teams intentions in connection with a visit to the site.

4.2.6 restrictions in respect of clearance operations

4.3 Employees relating information/evidence or witnesses must be told at the enquiry that the team investigates the cause of the accident in order that the legal position of the Company can be determined and that statements are absolutely privileged."

5. Enquiries

Preferably an enquiry should not be delayed until after court proceedings i.e. criminal proceedings, unless there is insufficient information to proceed. However, the rights of the accused in terms of the Constitution will have to be carefully taken into consideration, on each instance on an ad hoc basis. The broker/underwriters/attorneys may advise against the continuance of disciplinary enquiries if the evidence thereof is not likely to be privileged, or could have a bearing on civil liability.

5.1 Departmental Enquiries/Investigations

Departmental Enquiries are arranged to collate information necessary to establish the cause of an accident and thereby determine

5.1.1 the Company's legal position

5.1.2 remedial or other action required

If the Investigation Team/Board comprises of experienced line function Managers to cover all the relevant technical aspects it will only be necessary to call expert witnesses and it will not be necessary to extensively use witnesses to officially present the evidence to the team/board. e.g. if a member of the board witnessed the gauging of tyre profile or, did it personally, the information so obtained can be used by the team/board without calling a qualified witness to present the evidence.

N.B. No finding is to be recorded or conclusion reached

5.2 Disciplinary Enquiry

If a controlling officer is directed to take disciplinary action, the current Company instructions apply and if it leads to a disciplinary enquiry it will then be necessary to present all evidence officially

5.3 Department of Labour Enquiries

In the case of the Department of Labour enquiry, the procedure will be for witnesses to be called to present evidence to the Board of Enquiry. It is the responsibility and the prerogative of the Chairman of the Board to decide which evidence is to be used and how the evidence is to be presented. Where applicable, the annexure 1 forms are to be compiled and submitted in accordance with the current regulations.

5.2 Court Cases

Delegates from the Department of Labour the South African Police Service will also investigate certain incidents, particularly if people are killed or seriously injured or if crime is suspected. From information submitted to the Attorney General by either the SAPS investigating Officer or the Department of Labour the Attorney General may decide to prosecute Transnet as a legal person or its employees. In this instance evidence will also be submitted to the court by witnesses.

6. Admission of Liability

At no stage must any employee admit any personal liability of any nature on the part of Transnet/SARCC, unless he has been specifically authorised by the Chief Legal Advisor of Transnet.

7. <u>Statements/Incidents Reports Privileged</u>

Unless otherwise directed by the Chief Legal Adviser all statements taken, information obtained and all reports compiled should be marked as follows:

> "This document is privileged and is compiled for the purposes of obtaining legal advice from Transnet Limited's attorneys and for the purposes of possible litigation"

The reports are to be submitted to the Chief Executive or Regional/Metro Manager who requested the enquiry.

The Chairman of the Board/leader of the team must ensure that all documentation is included in the report and that all copies and unused material are destroyed and the information on the PC used for the preparation of the report is also cleared.

8. <u>Press Releases</u>

8.1 The Regional/Metro Manager is responsible for Press releases and for the correct information to be furnished to Corporate Offices and will decide whether Press liaison/PRO's will man the site offices and regional office respectively. It is imperative that the Site Co-ordinator be advised of the arrangement and that steps be taken to protect the Site Co-ordinator from harassment.

8.2 The following information can be released unconditionally:

- Arrangements for alternative transport for passengers.
- Details of hospitals where the injured were taken as well as other medical care arrangements.
- Details of the expected time of re-opening the line and normalising of the main service.

8.3 Information regarding the causes of the accident or payment in respect of injuries etc. must first be cleared with the legal advisor to ensure that Transnet/Metrorail/Spoornet is not admitting guilt.

8.4 **PRESS STATEMENT**

On .... the following happened

This has resulted in ......

The incident is under investigation by Transnet Limited (or Metro or Spoornet as the case may be) and brokers and underwriters.

Further information will be made available by the company when such investigations are completed.

9. <u>Call-out Procedure</u>

In the event of an accident/incident all the relevant parties must be informed as soon as possible.

9.1 Selected Managers are to be appointed as accident/incident Site Co-ordinators to take control of accident/incident scenes. As is the case with line function management, Site Co-ordinators will also have to be on stand-by in different areas to cover accidents/incidents of various extent. The responsibility and the authority of a Site Co-ordinator is discussed further on.

9.2 In cases where more than one operations room is functioning and also where decentralised call-out systems are used e.g. break-down depots a report back system should be introduced to the main operations office to enable the Site Co-ordinator to keep track of emergency operations.

10. Appointment of a Site Co-ordinator

10.1 As mentioned earlier it is considered necessary that selected Managers be nominated as Site Co-ordinators to function at the scenes of train accidents and that these officers be trained to manage disaster sites.

10.2 As a general directive it is recommended that accidental events be classified in the following categories viz:

10.2.1 Disasters - loss of lives and/or serious damage to assets (refer guidelines per attached annexure)

10.2.2 Accidents - one or two vehicles derailed or minor damage to property

10.3 Training

10.3.1 Background

It is imperative that a Site Co-ordinator has a good understanding of rail operations and should preferably be from Operations/Train Services, Rolling Stock or Infrastructure Departments, obviously with experience of train accidents. He should also be trained to legally proof evidence like visual material and how to obtain legal advice for the Company.

10.3.2 Legal Knowledge

In order to be able to handle the various aspects and activities encountered at accident scenes knowledge of common law as well as specific acts and/or company policies are essential. Arrangements will be made for suitable workshops for would be Site co-ordinators once the concept has been accepted and managers identified.

10.3.3 Emergency operations

Although it is not the intention that a Site Co-ordinator be qualified in the field of emergency operations it is imperative that Site Co-ordinators be acquainted with the various emergency services likely to be encountered at the scene and it would be of mutual benefit
if Site co-ordinators are included in local/regional disaster plan meetings and programmes.

10.4 As mentioned earlier it is necessary that Site Co-ordinators be on stand-by on call-out lists and be called out at an early stage. From their side the Co-ordinators on stand-by must ensure that they are within reach at all times.

11. <u>The role of the Site Co-ordinator</u>

11.1 The prime function of the Site Co-ordinator is to co-ordinate the medical, emergency and clearance operations and to enable investigating teams e.g. Department of Labour, Enquiry Boards etc. to collect all the relevant information and to furnish information to Public Relation Officers and Top Management for their information and for release to the press.

11.2 From the moment he is advised of an accident the Site Co-ordinator assumes responsibility and shall therefore immediately proceed to the site. (To enable the Site Co-ordinator to fulfil this function effectively it is essential that adequate communication facilities be made available to him.)

11.3 On arrival at the scene the Site Co-ordinator must attend to the following functions, in the order of priority dictated by the local circumstances.

11.3.1 Establish an operations room with adequate communication.

11.3.2 Survey scene to verify the adequacy of emergency, medical and break-down teams and to determine the status of the operations already in force.

11.3.3 Arrange for additional or other assistance.

11.3.4 Verify security arrangements and/or arrange for the demarcation of the site, access control, personal safety of all emergency teams and parking/road traffic control. Ensure that the press and identification and protection clothes (hard hats) are issued to persons permitted on site.

11.3.5 Suitably identify emergency and other officials permitted on the site to enable the SAPS and/or security teams to exercise access control.

11.3.6 Arrange and Chair regular site meetings to plan and programme operations. A person must be assigned to keep minutes of these meeting in sequence of the development of activities. All actions and decisions taken together with reasons should be documented.

11.3.7 Contact Department of Labour Inspector responsible for the investigation and inform him timeously of disturbances of the scene for emergency operations.

11.3.8 Establish contact with the departmental Board of Inquiry in connection with the collection of information

11.3.9 Manage the site and operations to the best benefit of the Company, Customers, Community and Stake Holders.

11.3.10 Ensure that the companies Chief Legal Advisor (and attorneys if relevant) Loss adjusters and brokers have been contacted by Spoornet and Metrorail Head Office.

11.3.11 Community leaders should be informed to facilitate the handling and quick dispersion of the accident/incident to the best benefit to the Company, Customers, Community and Stake Holder.

11.4 The Site Co-ordinator remains in office until the site is returned to the Line function management for normal Train Operations. (To be done officially)

12. Breakdown Teams

12.1 Break-down teams are called out either by the Train services/Operating offices or their departmental operational officers as per practice/agreements.

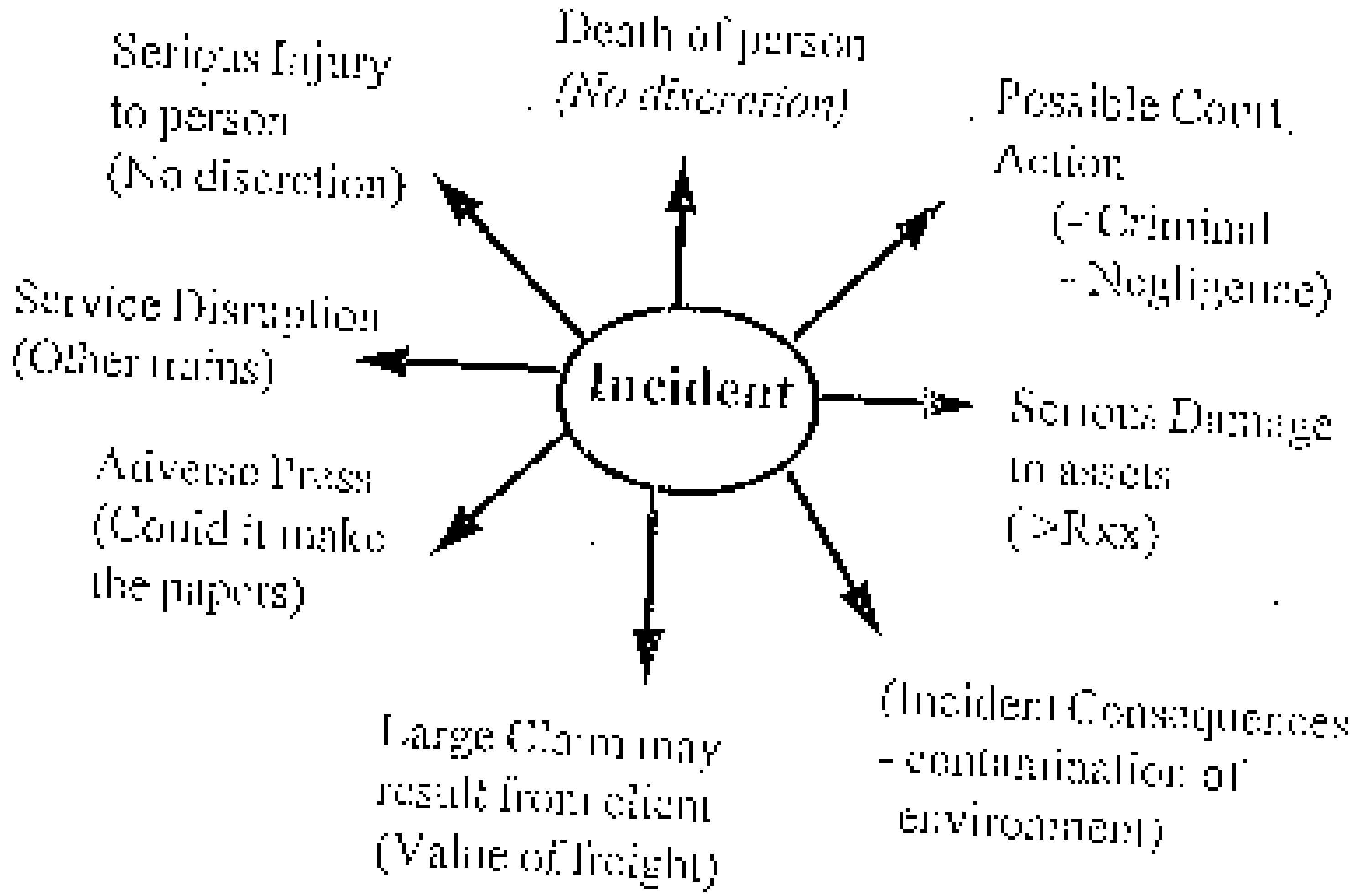
12.2 On arrival at the site, the break-down teams/staff will not commence with clearance operations without prior permission of the Site Co-ordinator and the issue of suitable access identification.

12.3 Safety/Protection operations such as earthing and/or removal of High Voltage lines, bird-caging of unstable vehicles etc. must obviously not be delayed but undertaken expeditiously at the discretion of the responsible officer/s.

13. Conclusion

In any event when clear up operations must be performed and investigations held it is of utmost importance to ensure that everybody involved must know what is expected of them.

SERIOUSNESS



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The Lord Charles Hotel, Cape Town, South Africa

Paper 9607

Bernard Thiel

Rewriting Train Working Rules From First Principles

CURRICULUM VITAE

Bernard Denis Thiel

Born in Johannesburg, 23 March 1941

- Obtained B.Sc. (Eng.) (Electrical) at the University of Witwatersrand in 1969.
- Joined South African Railways in December 1968, as Assistant Engineer, Signals
- Gained new works and maintenance experience on various regions as District and then Senior District Engineer
- Technical adviser to Swaziland Railways (1981 / 1982).
- Alternating current Traction supply signalling construction and maintenance on Coal Line, design work for major AC electrification projects.
- Manager of major signalling new works finances 1993 to 1995.
- Presently Senior Engineer (Signals) and member of Safe Rail Management Systems Committee and so is responsible for drawing up of Signalling Codes of Conduct and Codes of Procedure for Spoornet.

Re-writing Train Working Rules from First Principles

EXECUTIVE SUMMARY

Spoornet operating safety, in keeping with international aims, also aspires to the position of "the safest railway in the world". To achieve this, a well motivated staff, whose second nature is to always work safely, needs an up-to-date set of brief, yet relevant, Train Working Rules to govern all train movements. Using Principles of Safe Movement on Rail, developed by its own staff, Spoornet has set out to generate such rules. This paper reveals some of the methods and progress so far.

Re-writing Train Working Rules from First Principles

Introduction

The Train Working Rules of Spoornet have existed, in one form or another, since railways in South Africa began to run on a more or less organised basis. Such development is probably true of most railways in the world. The South African version was first drawn up for what was then the South African Railways (SAR) and Harbours Administration. They were known as the Train Working Regulations and required Parliament's approval for their introduction. Every new regulation or amendment that was introduced required the same statutory approval and the process was both cumbersome and drawn out. Amendments to both the old Regulations and the "new" Rules usually had one of the following reactive origins:

Changing clients' needs
Altered or new technologies
Varying traffic patterns
Results of the findings of boards of enquiry into train incidents.

Eventually, deregulation was recognised as the best way to streamline the maintenance of these regulations for running the SAR safely. Finally, in June 1978, the Train Working Regulations were no more, having been replaced by the Train Working Rules (TWR). These no longer needed Parliament's approval.

Did this reactive process really yield the best method of developing the most applicable format of the train working guidelines?

Not really. Because of the large number of rules, inconsistencies and contradictions began to creep in and rules covering obsolete systems and technologies remained unnecessarily in the TWR.

Avenues to the Solution

At present there appear to be at least three possible avenues for solving the difficulties facing Spoornet operating safety.

One is purely reactive and the other two are, to lesser and greater degree respectively, proactive (See Figure 1.)

The reactive method is to follow the historical path in which the rules evolve from day to day experiences.

The second way is to embark on the method of re-writing and rationalising the existing rules. It carries with it the risk of merely prolonging the existence of contradictions, anomalies and gross errors that do exist in the roughly 2[illegible] Train Working Rules that are in force today.

A third method is the road of determining the guiding principles which will yield all-inclusive and risk based simulated rules. Without too restrictive restrictions, this should allow staff to carry out their duties safely, effectively and efficiently whilst the company remains highly competitive with the other forms of transport that want to rob Spoornet of it's business. Top management decided on this third approach and, consequently, the Safe Rail Management Systems Committee (SRMSC) came into existence during August 1994.

The SRMSC set out to develop the Principles for Safe Movement on Rail. Initial acceptance of these principles by top management has led to their being renamed the Principles of Safe Movement on Rail (POSMOR). A paper on the development of POSMOR was read at the 1995 International Safety Conference in Mainz, Germany by the chairman of the SRMSC, Mr F Q Gallard.

The POSMOR were exposed to the railway safety fraternity worldwide in a number of international railway magazines and their validation was requested. An overwhelming and favourable response has been of great encouragement to the SRMSC although none have validated the POSMOR so far. Conditions were then ripe for the next phase of the process to be initiated.

Method Chosen

It was decided to follow the path shown in Fig. 2 to develop the new train working rules. Early in the process the lack of suitably experienced manpower was recognised by the SRMSC as one needing special attention. Arrangements were made to engage contractors from retired staff with the necessary experience and ultimately, eight men were secured. Most of these men had been involved in drawing up the existing regulations. They were placed under the consultant who had been retained as a member of the SRMSC because of his previous service as Assistant General Manager - Regulations.

The document hierarchy for the train operating environment is shown in Fig. 3 and 4. The POSMOR determine the company's policy regarding train operations. (See attached copy of POSMOR).

Two different groups of Codes of Conduct develop out of the POSMOR namely the Generic Codes of Conduct and Specific Codes of Conduct. Fig. 4 shows the four different safety modules which in turn each have their own Codes of Conduct in the form of chapters.

The chapters will deal with different aspects of each module.

Before the codes of conduct can be applied to lead in their turn to the Codes of Procedures in the Train operating environment, Guidelines will need to be formulated. These guidelines will help to interpret the codes of conduct to yield, on the one hand, Training Documents and on the other hand, the sought after detailed Work Safe Procedures (WSP), Rules and Instructions for the working environment i.e. The new Train Working Rules (TWR).

The train operating environment is presently governed by the latest Train Working Rules (TWR), the General Appendix No. 5 and individual Local Appendices for each of the ten regions into which Spoornet has been divided.

As part of the validation process, it was decided to give the contractors experience in applying the POSMOR. The existing TWR have grown into a massive monster which mixed everything from principles, codes of conduct (for various technical disciplines) to rules and instructions very specific to certain train control equipment not to mention the use of obsolete signalling and train control systems. As a first pass the contractors have removed all reference to such obsolete equipment and methods.

The second stage called for them to sort the TWR into correct document hierarchy, as indicated in Fig. 3. During this stage each aspect was tested against the POSMOR.

Definitions of terms have required special attention although every effort is being made to use the definitions in the Oxford Dictionary wherever possible.

Packaging the new documentation is vital and it has been decided to use the ISO 9000 format to manage the preparation of the re-written TWR and the speedy and reliable up dating of the issued documents. This has proved extremely difficult in the past and has led to a number of operating incidents which should not have occurred if the latest rules had been available to the staff concerned.

CONCLUSION

Much work remains to be done and there is an increasing urgency to get the new rules implemented as quickly as possible but this will require a paradigm shift throughout the Operating- and associated fields to make the transition a success. Already certain of the Infrastructure divisions have embarked on the task of teaching the new principles and an optimism exists.

I wish to thank my colleagues of the SRMSC for their input, encouragement and support in preparing this paper and the management of Spoornet for allowing me to present this paper.

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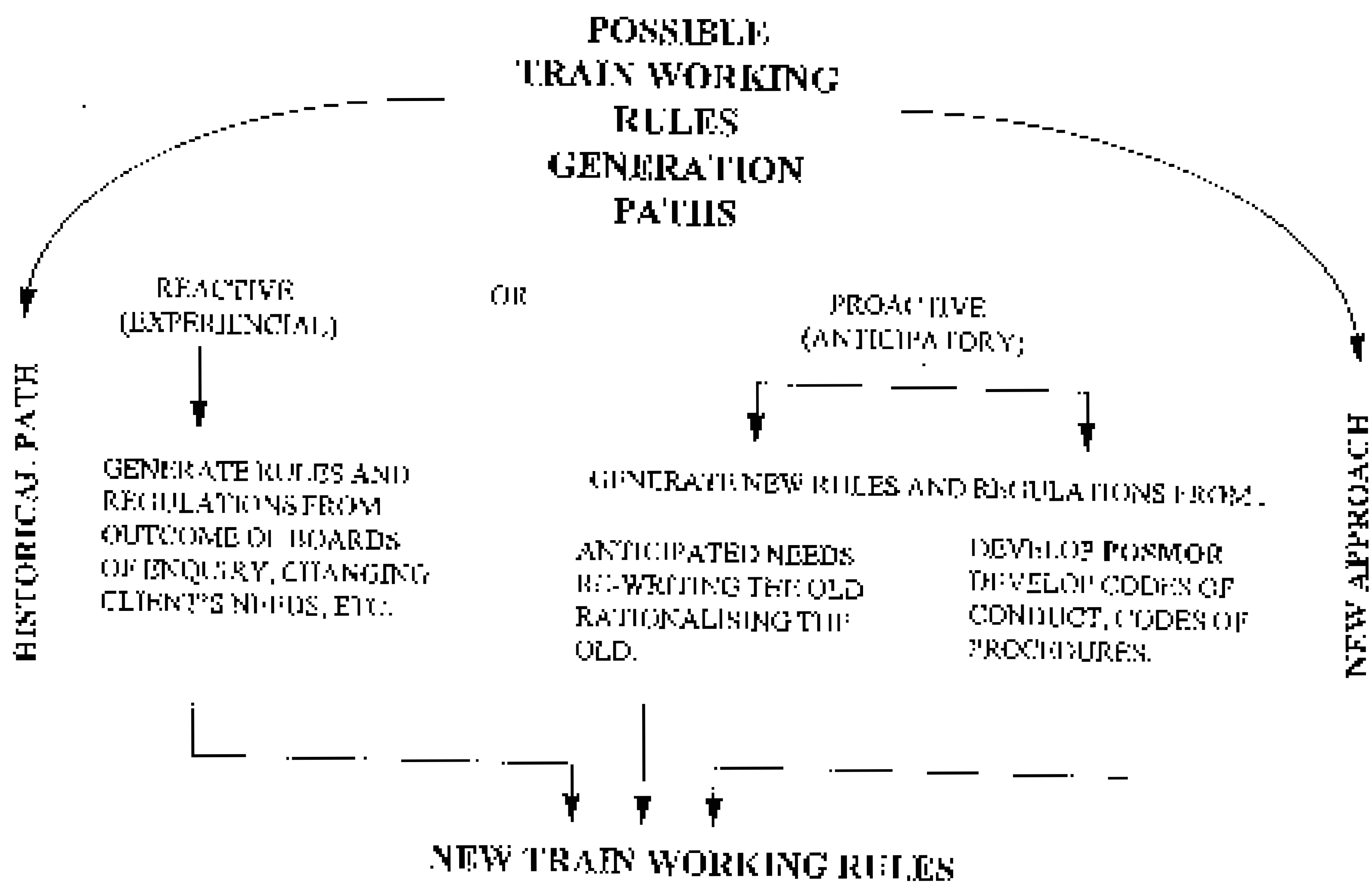
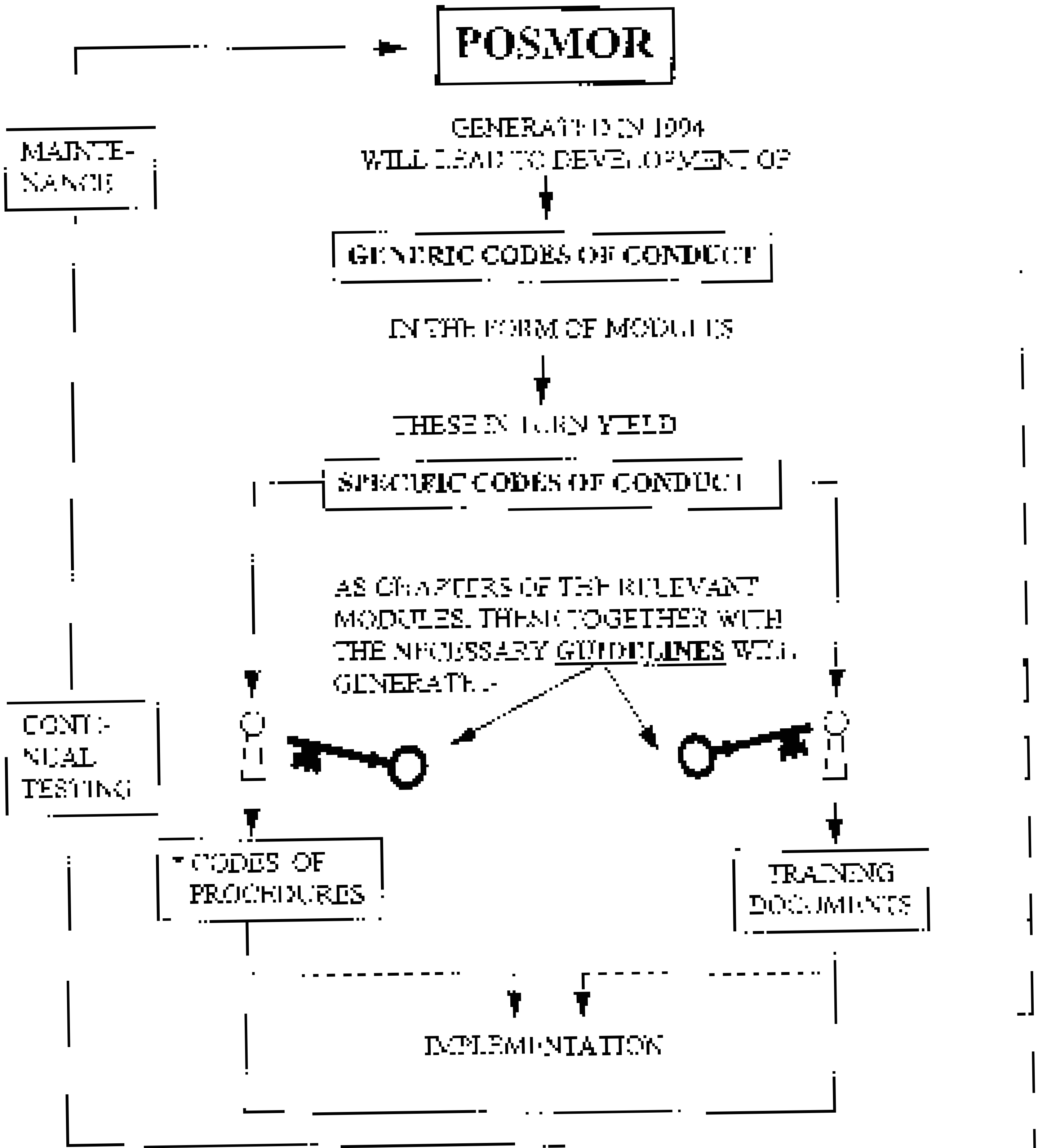
FIGURE 1



POSSIBLE TRAIN WORKING RULES GENERATION PATHS
HISTORICAL PATH
REACTIVE (EXPERIENCIAL)
OR
PROACTIVE (ANTICIPATORY)
NEW APPROACH
GENERATE RULES AND REGULATIONS FROM OUTCOME OF BOARDS OF ENQUIRY, CHANGING CLIENT'S NEEDS, ETC.
GENERATE NEW RULES AND REGULATIONS FROM:
ANTICIPATED NEEDS RE-WRITING THE OLD RATIONALISING THE OLD.
DEVELOP POSMOR DEVELOP CODES OF CONDUCT, CODES OF PROCEDURES.
NEW TRAIN WORKING RULES

FIGURE 3



*CODES OF PROCEDURE CONSTITUTED BY WORK SAFE PROCEDURES, RULES AND INSTRUCTIONS

DOCUMENT HIERARCHY - TRAIN OPERATING ENVIRONMENT

Policies (e.g. plastic card)	• Definition of principles • Excludes technology • Not time bound
Codes of Conduct	• A ruling document • To be used by all in the design/writing of manuals, instructions, etc. • No technology • Not time bound
Codes of Procedures	▪ Technology inclusive ▪ Works procedures - general ▪ Long term time frame
Working Instructions (can include job card and works orders)	• Technology specific application • Works procedures - specific • Short term time frame • Absorb modifications • Research and development procedures
Local Instructions	▪ Technology specific - geographically bound • Apply works instructions locally • Absorb local differences

Operating manual includes all above.

FIG. 3

ENVISAGED SAFETY MODULES

MODULE I	PRODUCTION	MODULE II	SUPPORT
Chapter 1	Safe Movement on Rail	Chapter 1	General Train, Shunting and Administrative Rules
Chapter 2	[illegible]	Chapter 2	Accident/Incident
Chapter 3	Protection	Chapter 3	Taking in / out of Service
Chapter 4	Communication - Verbal	Chapter 4	Maintenance
Chapter 5	Communication - Visual (Signals)		• Line - Infra
Chapter 6	Train Composition		• On Line - Rolling Stock
Chapter 7	Inter Railway Working/ Interface		• Control - Operating Systems
MODULE III	**SOCIAL IMPACT**	**MODULE IV**	**SPECIAL CATEGORIES**
Chapter 1	Public / Client Safety	Chapter 1	Passenger Trains
Chapter 2	Employee Safety	Chapter 2	Hazardous Consignments
Chapter 3	Sidings		• Identification
Chapter 4	Level Crossings		• Packaging
			• Handling
			• Incident / Accident
			• Communications (Special)

FIG 4

1. PRINCIPLES FOR SAFE MOVEMENT ON RAIL

1.1 PRINCIPLES APPLICABLE TO TRAIN AND SHUNTING MOVEMENTS

1.1.1 Before moving

- the track must be defined
- the defined track must be clear
- issue/obtain authority

1.1.2 Whilst moving

- adhere to speed instructions
- adhere to trackside and other indicators

1.1.3 Stop

- at limit of movement
- when and where scheduled

1.1.4 Whilst stationary

- stand clear (not foul)
- be secured (against movement)
- be protected

1.2 AUTHORITY

- shall be issued and accepted only by licensed persons
- shall have one meaning only
- shall not allow conflicting (following or opposing) movements
- holds good until executed or surrendered/withdrawn

1.3 COMMON TO MOVEMENT

- rolling stock must be serviceworthy
- infrastructure must be trainworthy
- authority to be issued, accepted and handshaken
- know location, extent and limitation
- consider feasibility of execution
- have continual communication

1.4 COMMON TO PERSONAL BEHAVIOUR

- be fit for duty
- be alert, vigilant and assess surroundings
- responsibility cannot be shared

1.5 COMMON TO ABNORMAL CONDITIONS

- have a hierarchy of fall-back procedures

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Paper 9608

Stanley Robertson

Experience in the UK of a Safety Case Management Regime

CURRICULUM VITAE

Stanley Stewart John Robertson

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Mr Robertson is a chartered engineer who has worked for the Health and Safety Executive for over twenty-two years. During this time he has held the posts of Head of Electrical Safety Standards, Head of Profession for all Specialist Inspectors and Regional Director of Field Operations.

Prior to joining the HSE he worked in the electrical supply industry, the nuclear industry and the petro-chemical industry. He took up his present post in February 1995. You will appreciate that Mr Robertson was appointed as a safety professional and not as a railway professional.

Experience in the United Kingdom of a Safety Case Risk Management Regime

by

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HM Chief Inspecting Officer of Railways
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United Kingdom

1. The New Structure of the Railways of Great Britain

1.1 The rail industry in Great Britain has undergone a period of rapid and significant change. Services which for more than forty years had been provided by a single, vertically-integrated corporation (British Rail) are now being supplied jointly by more than one hundred ones, and are in the process of being transferred to the private sector.

1.2 The most radical change in the new structure was the separation, from 1 April 1994, of infrastructure provision and management from train operations. A new company (Railtrack), now privatised, owns and manages the vast majority of track, signalling and other operational infrastructure of Britain's railways. Over thirty separate companies have been created to operate passenger and freight services, each of which must pay Railtrack for use of track, signalling and traction current.

1.3 Train operators obtain access agreements, which give them permission to use the infrastructure and set out the terms and condition of access :-

- from Railtrack, for use of track, signalling and traction current and
- from Railtrack or other operators, for access to any of their stations or light maintenance depots.

1.4 British Rail's freight business has been reorganised into a number of separate freight operating companies, each with its own rolling stock :-

- Three Trainload Freight companies, which transport bulk commodities such as coal and steel, and have been sold as a single entity
- Freightliner, which is a domestic container freight business, and has been sold to a management buyout team
- Rail Express Systems, which mainly carries Post Office mail, and has been sold to the Trainload Freight purchaser and
- Channel Tunnel freight services, which are being operated by British Rail's Railfreight Distribution division during their start-up phase, pending sale in 1997.

1.5 In addition, two other freight train operators have entered the market to handle own-account traffic, in competition with the established freight companies

1.6 Since 1995 private sector companies, and management and employee buyout teams, have been invited to bid to run domestic passenger services on a franchised basis. This process is being administered, and the resulting services monitored, by the Franchising Director, who while also provide subsidies where franchises attract negative bids (the normal situation). British Rail's constituent train operating units were restructured to become 25 train operating companies (TOC's) which form the basis of the franchises. To date, nine franchises have been awarded. Other than 14 major stations operated directly by Railtrack, every other Railtrack-owned station is leased to one of the TOC's, usually that providing the sole or main passenger service thereat.

1.7 The TOC's do not own their own rolling stock. Three specialist companies, all now in the private sector, own and lease out locomotives, coaches and multiple unit trains, and are responsible for their major maintenance and repair.

1.8 International passenger services via the Channel Tunnel are run by a separate company, in conjunction with French and Belgian partners. This company has been sold to the consortium responsible for building the projected high speed railway between London and the Channel Tunnel

1.9 Maintenance, renewal and modernisation of Railtrack's infrastructure is in the hands of 13 companies formed from British Rail's engineering arms, supplemented by several other private sector contractors. All these ex-British Rail companies, and most of the associated design and technical service consultancies, have been privatised.

2. Why The Safety Regime was Chosen

2.1 The potential risks of operating on a railway are such that any new organisation should not start operations unless it has, and can demonstrate that it has, an adequate safety management system, together with sound operating and technical standards. Existing railway rule books are the product of over a hundred years of learning from experience. No one can afford to relive this process, and moreover trial and error is not an appropriate basis for safety management on the railways. The public interest also demands that any newcomer company's claimed proficiency in relation to important areas of railway safety should be subject to searching scrutiny.

2.2 An infrastructure controller needs to apply safety related conditions of access to the railway network which it controls, and to become assured that any new operator is properly equipped and organised, so as to ensure that unacceptable risk would not be imported on to that railway system. Indeed, because an infrastructure controller has practical control of access and movement on the system (not least because of having control of the signalling), it is essential that the control is exercised in a way which ensures safety "so far as is reasonably practicable". This cannot relieve other operators of their own responsibilities, neither does it imply that the infrastructure controller is being given, or is taking on, an overtly 'regulatory' role. It is simply a question of appropriate arrangements to satisfy the infrastructure controller's own obligations.

2.3 An appropriate starting point in setting a safety regime was to require each railway undertaking (including infrastructure controllers) to produce a Railway Safety Case (RSC). The RSC sets out the risk assessment, safety management system, maintenance and operational arrangements in so far as they relate to health and safety issues. This incorporates the safety policy document, and the risk assessments required under general health and safety legislation, but needs to go further (see Section 3). Given the risks involved in getting it wrong, and the accumulated recommendations of various accident inquiries, this was not considered an excessively onerous requirement.

2.4 Experience, and the public interest, suggested that self-regulation (i.e. simply requiring an adequate RSC to be produced and followed) was not enough for satisfactory control of railway safety. In particular, there was a need to be able to show that a system was in place to have the key points of any undertaking's RSC 'validated' by another party. In effect, an operator's RSC is the means by which he seeks to demonstrate competence to an infrastructure controller, and the process of validation is the means by which such competence would be assessed.

2.5 Thus an important part of the infrastructure controller's own RSC is the 'validation' procedure by which it satisfies itself about the credentials of operators on its system in so far as they relate to the safety on the system itself. (This covers all major risk situations, but no process of review can be expected to verify every aspect of a safety case; and in particular an infrastructure controller could not be expected to validate specific procedures and arrangements for matters of minor importance, or those giving rise to risk outside its areas of control, for example safety aspects of the fitting out of the interior of passenger carriages.)

2.6 The Health and Safety Executive (HSE), as the safety regulatory body, satisfies its self that this 'validation' procedure is itself sound. This is done as part of a full assessment of the infrastructure controller's own RSC. This process, coupled with the inevitable monitoring of actual performance, enable HSE to profess itself satisfied that each railway undertaking has produced an adequate RSC and that all have been properly scrutinised, tested and found acceptable by a second or third party. This is termed a 'cascade' control model.

2.7 A development of this model would include a duty on HSE to specifically underwrite the process by itself issuing a safety validation certificate for each operator (perhaps following a submission from Railtrack). It could be argued that, as there is a direct HSE approval system for new works, rolling stock, etc., how can similar approval of an operator's organisation and systems, which might be much more important, be reasonably avoided? However there are other counter-arguments: it goes without saying that the resource implications of giving the HSE the duty to accept all validated RSC's of all railway undertakings would be formidable, and it would be a clear duplication of effort; and simply because there are existing 'approval' schemes for certain specific matters does not mean that all future enhancements to regulatory control should follow that route. The key question is which arrangement best assures safety? - if HSE were to take on the responsibilities which should properly rest with the parties themselves (particularly the infrastructure controller), it could undermine those responsibilities and reduce safety.

2.8 At an earlier stage British Rail proposed an alternative scheme, whereby HSE would have the specific responsibility for undertaking the validation exercise for all parties on the railway, and for issuing a certificate of acceptance. However, British Rail envisaged that the validation role would be 'contracted out' to a body headed by its own Director of Safety, and that HSE would act on that body's recommendation. There is little doubt that such a body would have had the expertise to do the job, but the arrangement proposed would appear to give it power without the corresponding responsibility. It would also put HSE in a position of dependence on a body which could withdraw, or might be wound up as privatisation progressed, leaving HSE without access to the expertise necessary to discharge its responsibilities. HSE might buy in support services, but, if it were considered necessary for HSE itself to undertake full validation exercises on each train and station operator, as well as each infrastructure controller, then HSE would have to be squarely in control of the process.

2.9 The remaining option would give HSE itself the duty to undertake safety validation of all the principal parties on the railway. This would share many of the problems already outlined, not least that of undermining the responsibility of the infrastructure controller and other parties. The HSE was not convinced that regulation at this level would be necessary to achieve the desired result, based experience in other high risk industries. There, arrangements for safety management of sites are firmly placed with the party in overall control of the premises, and a safety case or similar document includes the way in which other, subordinate parties, are monitored and controlled. This in practice is similar to the principle of HSE accepting the RSC of the infrastructure controller, but not to formally accept the safety arrangements of subordinate parties.

2.10 The basic cascade model (Para. 2.2 - 2.6) was adopted, and enshrined in law through the Railways (Safety Case) Regulations 1994. They apply to all railways, including those unaffected by British Rail privatisation, although there are exemption powers. Whilst it was considered appropriate to require the major non BR operators (principally urban electrified systems) to prepare RSC's and have them accepted by HSE, exemptions have been granted to many minor and preservation railways, which have been able to demonstrate less formally that health and safety is being properly addressed. Comprehensive guidance on the Safety Case Regulations, in the form of a booklet, has been produced by HSE for the industry (Fig. 1).

3. Nature of a Railway Safety Case

3.1 The aim of a Railway Safety Case is to demonstrate that the railway operator concerned can carry on his business with an acceptable level of safety. In order to do this, it must contain :

- a description of the railway operator concerned

- particulars to demonstrate that the level of safety will be acceptable. The Health and Safety at Work Act criterion that risks should be made as low as reasonably practicable is applicable here.

3.2 Contents

3.2.1 *Description of the Operation.*

The description of the railway operation should provide the answers to the following questions:

- WHAT will be done? (business activities, services provided)
- WITH what will it be done? (infrastructure, rolling stock, premises, plant equipment)
- HOW will it be done? (operating procedures, management systems, technical specifications)
- WHO will do it? (personnel)
- WHERE will it be done? (location of lines, stations)
- WHO ELSE is involved? (interfaces with other operators)

3.2.2 Safety Demonstration

This should include :

- a statement of safety policy objective
- identification of the hazards involved the railway operation
- explanation of the precautions taken against each hazard
- assessment of the residual risk of the railway operation, taking account of the likely effectiveness of the precautions
- justification that the risks have been made as low as reasonably practicable
- description of the safety management arrangements to ensure that the safety performance predicted by the safety case is maintained

- emergency planning

3.2.3 Interfaces

Where safety depends on the action of other operators, the description of precautions should make clear what arrangements have been made with those operators with regard to their safety responsibilities.

3.3 *Functions and Systems*

3.3.1
The safety of a railway operation will depend on the safety-related functions performed by systems.

3.3.2
In very general terms, a system can be considered as consisting of people, hardware (plant, equipment, infrastructure, etc.), and technical specifications and operating procedures. This is simplified to people, plant, and procedures in Fig 2. How well a system performs its function, and how safely it contains any hazard, depends on the interaction of these three elements. Thus :

- The design of equipment must take account of the human factors of the users, and the operating procedures they will follow
- The operating procedures must take account of the characteristics of the plant, equipment and infrastructure, and the competence level of the staff
- The staff must be trained to a level of competence appropriate to the procedures they must carry out, and to the characteristics of the equipment they will use
- All three must take account of hazards both internal and external to the system.

3.3.3.
Maintenance of the safe performance of a system, taking account of future growth and changes, is the task of safety management.

3.4 *Types of Operator*

3.4.1
The Safety Case Regulations envisage three types of railway operator: infrastructure controllers, train operators, and station operators. It is possible for an operator to be responsible for any combination of these operations.

3.4.2
The main safety functions of each of these railway operators are as follows:

(a) *Infrastructure Controller*

- control the safe movement of trains
- maintain the infrastructure in a safe state
- ensure that train operators meet safety requirements regarding the safety of the infrastructure and the safety of other trains (including those of other companies) on the infrastructure
- ensure that station operators meet safety requirements
- Ensure the health and safety of persons on the infrastructure, both employees and others

(b) *Train Operator*

- Move trains safely in accordance with procedures laid down by the infrastructure controller
- maintain trains in a condition consistent with the safety of the infrastructure, people on board trains and other trains on the infrastructure
- ensure the safety of people boarding or alighting from trains
- ensure the health and safety of people, both employees and others, on board trains

(e) Station Operator

- ensure the safety of people boarding or alighting from trains
- ensure the safety of people passing through or waiting at their stations
- make adequate arrangements for the emergency evacuation of stations
- take adequate precautions against the hazards of overcrowding

3.4.3
The above lists of safety functions are not exhaustive. Particular functions will depend on the nature of specific operations.

3.5 *Role of the Railway Safety Case*

3.5.1
A high degree of co-operation and co-ordination between operators is required for these safety functions to be performed effectively. The Safety Case Regulations impose a duty of co-operation on all railway operators, and require them to set out in their Railway Safety Case (RSC) how safety will be achieved. The duty of co-operation gives legal form to what is no more than common sense, or at least enlightened self-interest, to the users of a common infrastructure. The RSC should make explicit the operator's systems for providing each of the safety functions.

3.5.2
A more detailed view of the role of the RSC can be seen by taking the example of the infrastructure controller's function of controlling the safe movement of trains. In order to demonstrate that this will be achieved from the outset, the RSC must identify the potential hazards to train movement against which the control arrangement must protect. The numbers and competencies of people responsible for train control should be stated, the organisational structure within which they work should be outlined, and safety responsibilities should be identified. There should be a description of the signalling and communications systems which will be used and details of the operating rules and procedures which will be followed.

3.5.3

Because it must be demonstrated that safety will be maintained throughout the life of the operation, the RSC should contain enough details of the safety management system to demonstrate that the fitness and competence of staff will be maintained, that effective two-way communication exists to ensure that safety problems are reported, that changes in rules and procedures are properly communicated, and that the performance of the system will be monitored so that actual or potential causes of harm are identified and remedied.

3.6 *RSC Preparation and Assessment*

3.6.1

To prepare an RSC capable of demonstrating the safety of all aspects of a railway operation appears a major task. It should not, however, involve the operator in much more than collating and codifying all the procedures, practices, organisational and safety arrangements, which would have to be put into place anyway for a safe railway operation.

3.6.2

Outside professional help can be valuable in preparing certain aspects of an RSC, but it is important that much of the content should be provided by those who will be required to make it work in practice. This should ensure that the RSC reflects a full understanding of the operation and its associated risks, and will foster a sense of ownership and commitment on the part of all concerned with the operation.

3.6.3

The schedules and guidance in the Safety Case Regulations set out and explain the information required in the RSC from each type of operator. It is not possible to be definitive about the level of detail to be included, but a good rule of thumb is that the more novel the operation, the more detail will be required to demonstrate its safety.

3.6.4

Assessment of an RSC involves firstly a check to ensure that all of the information required by the Regulations has been supplied, and then a careful analysis to establish that the safety of the operation has been demonstrated. One way of doing this is by seeking the answers to a series of questions designed to establish the safety of a particular function. Taking once more the example of the safe control of train movements, an assessor's list of question might be as follows:

- Is there a suitably structured, adequately resourced, competent organisation to control railway operations?
- Do the standards, procedures and arrangements for railway operations comprise a proven set of rules and instructions?
- Are there adequate arrangements for communicating operating instructions and notices within the organisation?
- Are there adequate arrangements for ensuring that operating instructions, notices, etc. are communicated to train operators?
- Is there a suitable structured, adequately resourced and competent organisation to develop and revise operating instructions and arrangements?

3.7 RSC Acceptance

(a) The Safety Case Regulations provide for a chain of acceptances of RSCs (Fig. 3) as follows :

- For an Infrastructure Controller, by HSE; this has to include the arrangements for accepting RSCs of train or station operators, where such other companies use its infrastructure
- For such Train and Station Operators, by the Infrastructure Controller concerned

(b) The chain of acceptance ensures that there is consistency between the various operators on a given railway, with the infrastructure controller taking the lead in ensuring overall safety. It also ensures that RSCs are accepted by a body independent of the preparer and user: no one is allowed to accept their own RSC.

(c) After acceptance by an infrastructure controller, there is a 28 day period before commencement of operations is allowed, for HSE to scrutinise the documents, and to take action if any matters have not been correctly considered.

(d) Where a company is both infrastructure controller, and train and/or station operator, a single RSC for all aspects is prepared for acceptance by HSE. HSE also accepts RSCs for stations servicing more than one infrastructure controller, and those actually owned other than by the infrastructure controller.

3.8 RSC Operating Regime

3.8.1. A railway operator has a duty to conform to its accepted RSC. An infrastructure controller, who has accepted RSCs from train or station operators, has a duty to ensure that they follow the procedures and arrangements described. In an extreme case, where an operator is considered to be operating in a dangerous manner, the infrastructure controller might have to deny continued access to the network.

3.8.2 The reasonable requests of the infrastructure controller, with which train and station operator are required to comply, include day-to-day operational matters such as temporary speed restrictions, diversions, and platform alterations. They may also include requests for access for operator's premises for monitoring or audit purposes.

3.8.3 An RSC should provide a guide to the policy and arrangements for safety of the operation concerned. It is a means of focusing on the safety aspects of all systems, not only for the railway operators themselves, but also for HSE as the independent safety regulatory authority.

3.8.4 The RSC must not be shelved and forgotten after acceptance. It should be an organic part of the management and control of the railway operation. As such, it should be regularly reviewed and updated in the light of experience and whenever changes to the operation are contemplated. Where such changes would make the RSC materially different from the accepted version, the changes have to be submitted for acceptance, in the same way as new documents. And, in any case, a formal review has to be conducted at least every three years.

The Way Ahead

4.1 RSCs were introduced from 28 February 1994, with existing operators having a two-year transitional period to produce an RSC and have it accepted.

4.2 The introduction of RSCs has enable an approach to safety regulation to be adopted which covers all aspects of a system and all stages of its life. Fig. 2 represents the essential elements of a system, and FIG 4 shows how the HSE's activities span its whole life. The process encompasses approval of the infrastructure and rolling stock (the "plant"), acceptance of the RSC (the "people" and "procedures"), inspection and audit, collection and analysis of safety performance data, and investigation of accidents.

4.3 A major part of HSE's activities is now directed towards answering the following questions :

- are the railways working to their RSCs?
- are the RSCs working?

The former question sums up much of HSE's mainstream inspection work, while the latter is aimed at seeking areas for improvement in the system.

4.4 The RSC is an excellent starting point for understanding how a railway operation is intended to achieve its safety goals. This enables HSE to adopt the techniques of theme inspection, where a particular aspect of the operation is chosen, for example an infrastructure controller's management of infrastructure maintenance, with the RSC being used to identify what is relevant, actual performance is compared with the relevant standards and procedures. This enables a much greater in-depth understanding of the performance of the operation, than can be gained from random or systematic on-site inspections alone.

4.5 The RSC also gives greater coherence to the findings of the traditional (and still indispensable) inspector's site visits, as it provides the means of identifying systematic weakness which may underlie individual lapses or omissions.

4.6 These approaches to inspection should be equally valuable, when used by an infrastructure controller to monitor the compliance of train or station operations with their RSCs, or when used by operators as part of their own internal audit and monitoring regime.

4.7 RSCs have generally been based on continuity of technical standards, operating procedures, and competence and experience of people. Thus, while their introduction has been a step change in the regulation and management of safety on the railways, but it was not expected to produce an immediate change in the level of safety achieved in the industry. The main objective of the system was to ensure that existing levels of safety were maintained during the reorganisation, fragmentation, and subsequent privatisation of British Rail into successor operational organisations. This has been achieved, and forms the basis of continual gradual improvement in the future. In the longer term, however, it may be hoped that the more comprehensive systematic approach to safety, provided by the effective use of RSCs will lead to the evolution of greater safety, as lessons are learned and best practices are shared between different parts of the industry.

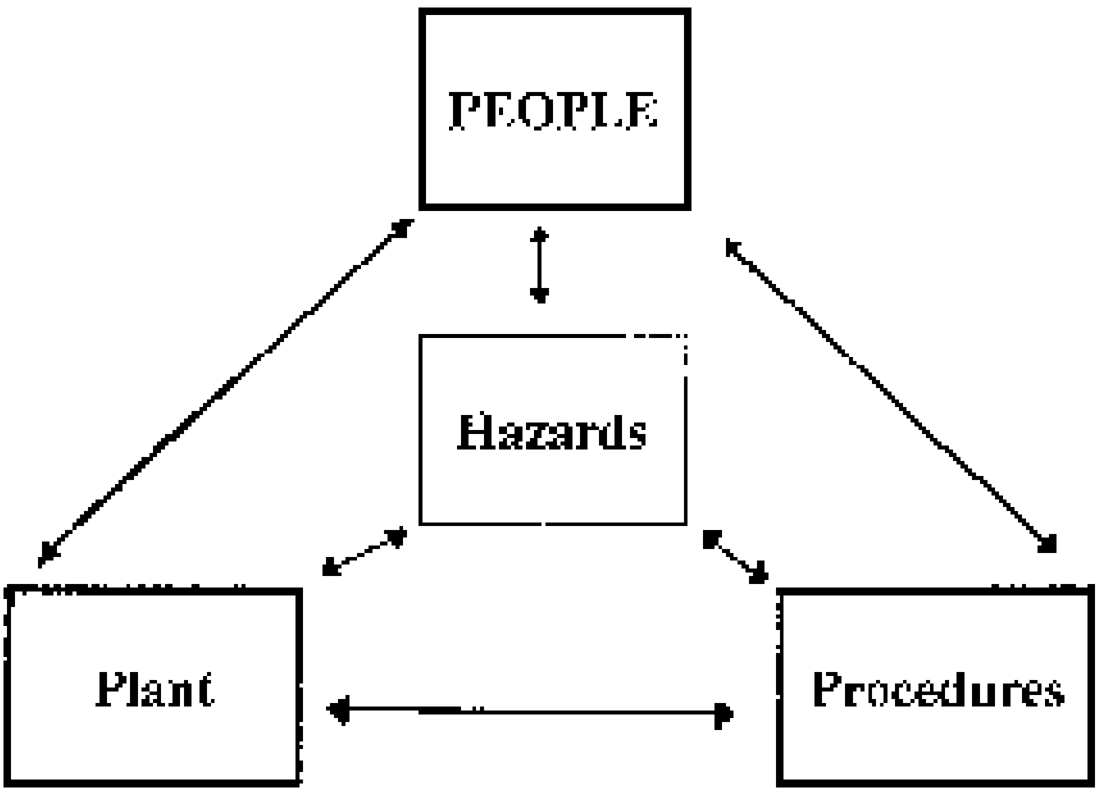

FIG 2: Elements of a System

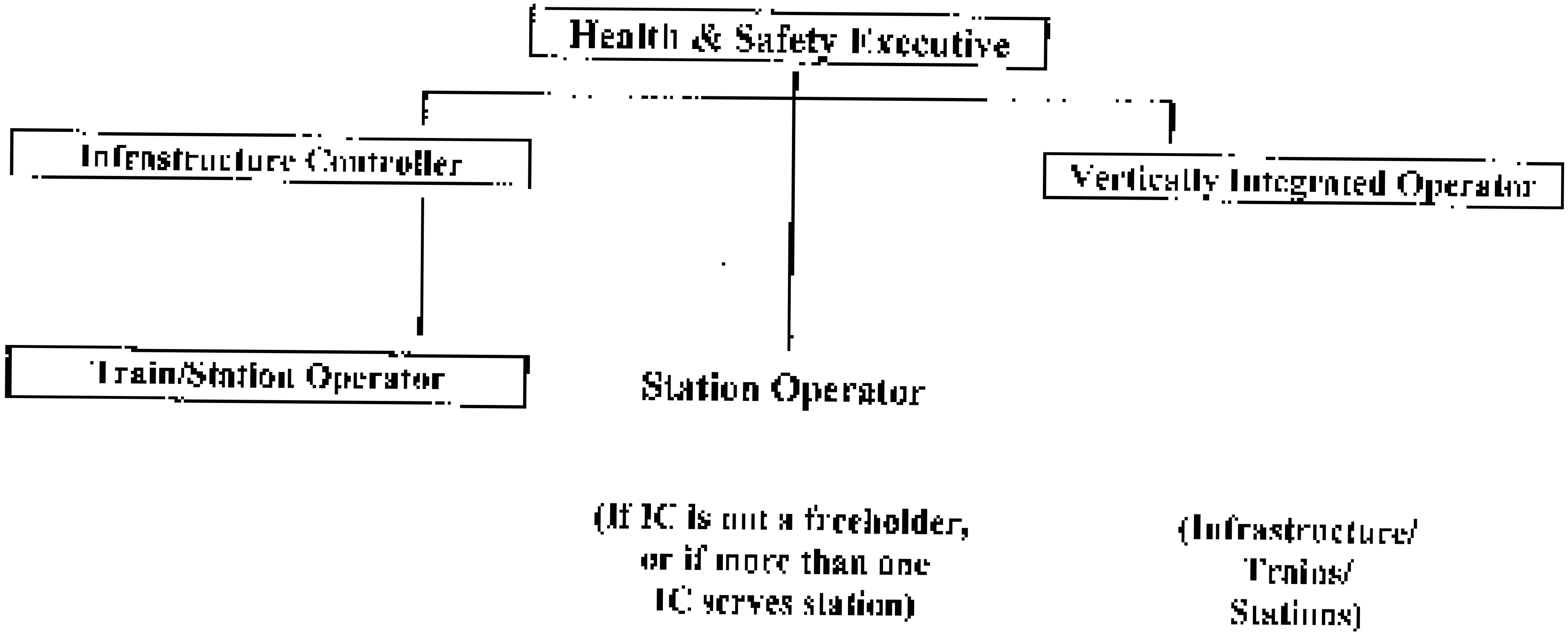

FIG 3: Railway Safety Case Acceptance Chain

Approve Infrastructure and rolling Stock

Accept Railway Safety Case

Preventative Inspection and Audit
All aspects of safety)

Collect and Analyse Safety Performance Data

Investigate Accidents

FIG 4: HSE's "Whole Life" Railways Activities

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Tony Roche

Developing a Safer Railway: The Role of Research in a Changing Industry

CURRICULUM VITAE

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Tony Roche joined British Rail in 1959. He was initially employed by British Rail Workshops, ultimately becoming Works Manager at Wolverton. Following a European commercial management appointment with BRML, he was engaged in the disposal of Railway Workshops to the private sector.

In January 1991 he was appointed as the Director of Mechanical & Electrical Engineering and in June 1992, he became Deputy Managing Director of Network South East. In early 1994 he took a leading role in developing and creating the Rolling Stock Leasing Companies and was appointed Managing Director of one of these companies. He retained his role as Chief Executive of BRML during these appointments.

From June 1994 he became Group Managing Director, Central Services, responsible to the Chairman of BRB for executive direction of all Central Services activities; the three Train Engineering Services Companies; the Board's Safety Directorate; Quality and Procurement & Materials Management.

He was appointed to the Board of British Rail in April 1996.

Developing a Safer Railway: The Role of Research in a Changing Industry

by

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Introduction

We all understand the importance of research and development for any company or organisation, whatever its chosen field. Research, and the subsequent development of improved products and services, is an essential step along the path of continuous improvement. It is as important in the rail transport industry as it is elsewhere and it is particularly relevant to the improvement of safety.

It is probable that virtually everyone at the conference is involved with change in some way at the moment. It may not be as fundamental as the privatisation programme taking place in the UK but restructuring, privatisation and commercialisation are words with which we are all very familiar.

This paper will trace the development over the past four decades of research on Britain's railways, to analyse the ways in which it has been and is still being affected by the changes taking place in the industry at the moment, and to consider its role and structure in this new fragmented industry. As this is a safety conference, the paper will concentrate on the contribution of research to developing a safer railway.

In the paper, research is being considered in two ways - applied research and strategic research. Both are important to the process of continuous safety improvement, but applied research often has more transparent links with the eventual measure of failure or success of the work.

Strategic research, or pure research as it is sometimes termed, has wider horizons, may not have such a clearly defined outcome, and it is measured in terms of longer timescales. Because it poses the greatest challenges to the changing industry, the paper concentrates on safety-related research.

Inevitably the paper will focus on the situation in the United Kingdom, but it should have relevance to all of you at this conference.

Historically, British Rail (BR) has held an important position in applied and strategic research in the UK. Under the 1968 Transport Act, British Rail was required to undertake research and development, acknowledging its unique position in the rail transport industry in Britain.

Even prior to the 1958 Act of Parliament, the British Railways Board had recognised its responsibilities and the importance of research in spearheading the modernisation of Britain's national rail network in the late 1950's and early 1960's.

Many years ago, the British Railways Board recognised the need for a proper focus of strategic research effort and established a Research and Technical Committee. This Committee, as well as involving BR engineers and managers with key skills, also included eminent figures from the UK academic and industrial fields. They were able to add an extra dimension to the work of the Committee by giving a broader view, and their value to the work of the Committee has been considerable.

The Committees role was to steer the strategic research programme and to manage the annual strategic research budget of several million pounds which BR invested in the work of Railway Technical Centre, and BR Research in particular. Even after the restructuring of BR into a number of semi-autonomous companies, the strategic programme was still managed at corporate level because the Board recognised its importance to BR.

British Rail Research

In 1957, BR established a centre of excellence in the form of the Railway Technical Centre at Derby. There, a whole range of skills and research facilities were created to tackle the vital task of modernising the railways in Britain. It was a bold step with significant government funding, but it enabled British Rail to establish a leading position in research amongst the world's railway administrations. Success can be gauged by the fact that many innovations developed at the Railway technical Centre have been exported all over the world.

Amongst its other achievements, the Railway Technical Centre (RTC) and British Rail Research, as the research arm of the RTC became, were a number of initiatives which made a substantial contribution to the improving safety performance of British Rail.

A good example is the work associated with "crashworthiness" or the extent to which a vehicle is able to withstand the forces of collision and derailment. Over the past twelve years British Rail research has carried out several programmes of work covering structural and interior crashworthiness. The Clapham Accident in 1988, in which 35 people died and over 500 were injured, added a new stimulus to the work, and the report of the accident made specific recommendations for improving vehicle crashworthiness.

The substantial body of work in these programmes covered a wide span of research and development, including accident analysis, the use of mathematical models, vehicle design and materials, driving cab modifications, and work on the overriding characteristics of vehicles. This work led to the production of revised specifications for the performance of the external structures and interior fitments of rail vehicles which would substantially reduce the number and extent of casualties in the event of a collision.

A strength of the work outputs was the recognition to the relationship between costs and benefits, between risks and the cost of control measures, and the need to understand these relationships to ensure the maximum safety benefit.

This example demonstrates some of the applied research & development which British Rail has led in the last few years. However, the list is much longer and covers a wide range of safety related areas, including improved methods of track maintenance and renewal, wheel slip protection systems for poor adhesion conditions, and train movement computer control systems.

There have been some failures as well, but research work by its very nature has an uncertain outcome, although overall our record has been good.

Strategic research became an increasingly important area of focus for British Rail. This was partly because of the loss of British Rail's own in-house manufacturing capability in the late 1980's which shifted the focus of applied research in some areas to the suppliers. It was also partly because of the increasing international dimension of strategic research. British Rail has always had active, direct links with international railway research organisations and other railway administrations, but these links have strengthened and increased in the last few years.

Privatisation and it's effects

The Railways Act of 1993 initiated the process of privatisation of the national rail network in Britain by separating the control of infrastructure from the operation of trains. It created Railtrack, the infrastructure controller, three rolling stock leasing companies who own all the passenger rolling stock (the ROSCO's) and a number of autonomous train operating companies.

Over the last two and a half years, the privatisation process has gained momentum. Railtrack is now a private company trading on the Stock Market, the three ROSCO's have been sold (and one subsequently resold), and the British Railway Board now owns only eighteen out of thirty five train operating companies it once owned. By the Spring of 1997 - less than twelve months away - the British Railways Board will no longer be a trading company, and the industry will be composed of a large number of relatively small companies.

The continuing importance of research to the railway industry and its vulnerability at a time of such change was recognised by the Health and Safety Commission (HSC) in a document they produced in 1993 in response to the Government's proposals for the privatisation of British Rail. (The operational arm of the Health and Safety Commission, the Health and Safety Executive, has responsibility for the statutory regulation of safety on Britain's railways).

In this document, "Ensuring Safety on Britain's Railways", the HSC identified the need for the new smaller companies to have access to expertise in research, development and technical support. Their recommendations in the report, quoted below, was accepted by the Government.

"The need to ensure that appropriate facilities for safety, research and technical evaluation remain available to railway undertakings in Britain should be borne in mind by the Department of Transport when developing proposals for any disposal from the public sector of the existing British Rail research and development facilities."
That process of sale of British Rail Research has already started and it is the intention that British Rail Research will be sold before the end of 1996.

So what is the present position ?

Even during the current year, British Rail's Research and Technical Committee has been managing a reducing programme of strategic research, however the last meeting of the Committee was held only last week. There is little more that British Rail can do other than contribute to the debate. It is for the industry as a whole to determine the way forward.

Hopefully this has given you a brief perspective of the historical role of research in the process of developing a safer railway in Britain. But what of the future of strategic and applied research ? Who will take on that role in the future ?

A view of the future

As mentioned earlier, the pattern of British Rail seeking design and manufacture from external sources has already been established. It goes without saying that there is an increasing role for suppliers in carrying out research and developing new products to meet the needs of their customers. This process has already started and will continue whether the customer is British Rail, Railtrack, or the owner or operator of the asset. It is the way the world works in a commercial environment. Legislation also places on suppliers an obligation to ensure component, product and system safety.

What is likely to happen, is that the larger, more powerful suppliers who can operate on a global basis will increasingly aim to meet the needs of the international railway markets. They will design the product, build it and in some circumstances maintain and maybe in due course operate it, using research and development work aimed at a global market. There will probably be a greater emphasis on cost-effectiveness rather that major technological development and this may apply as much to safety as to other aspects of performance.

The position in the future is not so clear as regards strategic research.

In the case of an integrated railway, it is easy to see who should take the lead in strategic research. But what about research into new technology that could affect the safety interfaces e.g. the train/signalling interface in the new fragmented industry. Bear in mind that the failure rate and cost of strategic technology can be high, and the direct payback is uncertain.

Should it be the infrastructure controller ? Clearly, the infrastructure controller must take a lead in issues affecting the safe operation of the infrastructure, which includes the running of traction and rolling stock over that infrastructure. But what about research that could improve the ability of the driver to control the train so that the risk of collisions is reduced?

Is that where the train operator fits in ? Possibly, but a train operator with a franchise to operate for seven years may see little benefit from that research before that seven year period is over. Improving the safety performance of existing assets using applied research and development rather than a more radical solution makes more sense.

So what about the owner of the rolling stock ? Perhaps, but providing that a train operator does not reduce the value of the asset leased from the ROSCO, and unless there are obvious benefits in increased lease charges from the improvements which may eventually derive from strategic research, the rolling stock company may see little advantage.

This paper has deliberately over-simplified the position. In reality they all have an interest in strategic research if it yields the potential benefits. But who takes the lead ?

What about strategic research associated with infrastructure maintenance ? This maintenance is carried out entirely by contract for Railtrack. Railtrack will expect the contractors and their suppliers to develop more effective and safer ways of maintaining the infrastructure. However, funding and leading research in areas that may not yield results for several years, if at all, will inevitably fall to the owner of the infrastructure.

There is also the important issue of strategic research in co-operation and collaboration with our railway colleagues in other countries, with Government research bodies, and with the universities. The UIC is already wrestling with the problem of the appropriate ways of representing a fragmented British rail transport industry, and the same problem applies with strategic research at an international level.

The question of funding is also important. British Rail in 1993/1994 in the last year it controlled an integrated railway had revenues of £ 3.6 billion and was able to fund a fairly modest programme of strategic research of £7 million. A small train operator with a turnover of £20 million is in quite a different position.

Indeed, who actually sets the policy in the UK which will determine the direction in which strategic research will be steered ? Who will carry out the research ? If the research is successful, how will the benefits of the research be shared in relation to its costs ? Consider the example of a successfully developed cab borne signalling system? Whoever funds the initial research and development, how will the eventual implementation costs and benefits be shared between the vehicle owner, the train operator, and the infrastructure controller.

There are a whole range of issues which are pertinent to this debate and several of them have been deliberately raised in a rather simplistic way to emphasise that these are important questions which need answering. Some of them may well be relevant to you in some shape or form.

We must also pay particular heed to the public view of safety. We have always been heavily committed to running a safe railway and our success is demonstrated by the fact that the public tend to take safety on the railway for granted. But that perception, and the value that the public put on safety, is constantly evolving. If we fail to recognise that, and fail to work towards a goal of continuous improvement in safety, then we face a very uncertain future indeed.
It is pleasing to note that since April 1994, the safety record of UK railways has continued to improve in the early days of the new industry structure.

Having recognised the importance of getting it right and not creating a damaging research vacuum for the next few years, the Government's department of Transport has sponsored the formation of a committee to review future research and development in the railway industry. The Committee's role is to advise the Department of Transport on the best mechanism for directing and co-ordinating research and development in order to meet the needs of the new railway industry.

I must declare an interest at this stage. I am a member of that Committee. The Final report has been prepared but has not yet been released, therefore it would be inappropriate for me to give details. However, let me share a few thoughts of my own on some of the key issues which the industry needs to face, particularly in the vital field of safety.

I readily acknowledge the important role of the supplier in applied research and by developing safer products for the industry they should also be improving their own competitive position.

It is also essential that we get the balance right and let the industry players respond to the needs of the market without attempting to give central direction where it is not needed.

Having said that, we would all recognise that there are areas of safety related research and development where for the industry simply to rely on the efforts of the suppliers could lead to a research vacuum being created. This is particularly so of issues which provide an interface between different players in the industry. The example quoted above of the train/infrastructure interface makes the point.

There is also the future of what is called "blue-sky" research - using strategic research to help us develop a vision of the train of the future, to help the industry to consider radical infrastructure developments, for example, which could align to Government aspirations to transfer road traffic to rail. If we can create a shuttle service for road vehicles through the Channel Tunnel, why not from Glasgow to London, or, better still, from Glasgow to Rome?

Where national Government or European development, or even public opinion where rail safety is concerned, leads to a change of emphasis in rail transport policy, then some kind of central co-ordination is essential for progress to be made. That co-ordination must involve not only the policy makers but those who will need to respond to the policy.

The issues of safety related research and development we are facing and the way in which we deal with them will, I believe, play a large part in helping to determine the future role of railways in Britain. There are lessons which can benefit other railway operators in the world who may be travelling to a greater or lesser degree, along the same path of industry restructuring.

Conclusion

The paper has covered briefly the historical background of safety-related railway research in Britain and summarised what are considered to be many of the key issues which the industry will have to face if it wishes to ensure that research continues to play an important role in developing a safer railway. Some of the issues may not have a simple resolution. The reassurance is the willingness of all parties to appreciate that the issues are important enough to demand resolution, and the evidence that progress is being made in maintaining the vital role of research in developing a safer railway in the changing industry.

International Rail Safety Conference

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The Lord Charles Hotel, Cape Town, South Africa

Paper 9610

J. Steyn
L. Bradfield

Rail Safety: "For Africa from Africa" An audit with a difference

CURRICULUM VITAE

J. J. Steyn

Graduated in Civil Engineering in 1972 and has a career history as follows:

1972 - 1988

Employed by South African Transport Services as Assistant Engineer, District Engineer and later on Assistant Regional Engineer. He worked mainly on perway maintenance and spent two years on the Coal Line construction at Vryheid.

1988 - date

Senior Manager, Infrastructure for TransNamib Limited, Namibia. Responsible for Track, Building and Structures, as well as Telecommunications.

CURRICULUM VITAE

L. L. Bradfield

Director, Bradfield Concept Engineering c.c. (BCE)

Nature of business:

Engineering consulting, Market Research, System Engineering and Project Management from Concept through Industrialisation to Logistic Support. Railway consulting, specialising in train/track dynamics. Capitalising on very practical background, complemented with many years in R&D to generate simple, effective solutions, fast.

Past employment includes:

South African Transport Services, Chief Mechanical Engineers Office, Pretoria
AC Locomotives, Assistant Mechanical Engineer

1965 - 1968
Clerical
1968 - 1972
Millwright - Mechanical Maintenance in Harbour and Mechanical Workshops
1972 - 1977
Draughtsman (Mechanical) and studied full-time for BSc Engineering Degree
1978
Engineers Induction Course
1978 - 1980
Production - Due to background he was placed in charge of all production in East-London workshops
1980 - 1986
Research and development, Pretoria
Reached the position of Mechanical Engineer (Train Dynamics) and specialised in Rail/Wheel interaction
1986 - 1987
Assistant Mechanical Engineer, AC Locomotives

Rail Safety

"For Africa - From Africa"

An Audit with a difference

by

J.J. Steyn
Senior Manager
Infrastructure
TransNamib Rail Division
Namibia
(Project Co-ordinator)

and

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EXECUTIVE SUMMARY

A safety audit of the TransNamib Rail Division (TNR) is conducted against a background of economic and cultural change as they adapt to remain aligned to their company vision and mission. Recognising Namibia's transport needs and the local market competition and limitations, TNR has embarked on a unique customised, Southern African - specific approach. The safety audit is the first phase in a program to increase train speeds and reduce delivery times, while maintaining a high safety standard, in an attempt to meet projected market opportunities.

This is a safety audit with a difference, in which both auditing and corrective actions occur in parallel. A unique participative approach between the contractor/specialists and TransNamib staff (Audit team) is spread over a 7 month period. Interaction and time play a significant role in the transference of knowledge and the understanding of the need for change. Team members, representing all relevant departments, are exposed to a holistic approach, crossing discipline/departmental barriers and creating an awareness of their inter-dependence and the consequences of their decisions on others.

The need to move away from a military style detail explicit safety approach, to a knowledge based one in which regulations are more generic, reinforced with performance measurement and feedback, is exposed.

The emphasis is focused on present application and future safety needs regarding :

- train/track dynamics
- maintenance standards and practices
- knowledge and skills of key personnel

Critical items are identified and high risk/cost areas attended to immediately, allowing operating budget savings to offset project costs, making it possible for the project to run on positive cash flow.

Economic common sense excludes the consideration of drastic changes to rolling stock and track infrastructure, as seen in First World countries like Europe and Japan. Limitations in existing infrastructure, market size and finance, challenge the teams intellect to produce appropriate solutions. Technology is transferred and a small Train-Dynamics office is proposed within TransNamib to monitor, assess and implement relevant technologies.

A low cost, appropriate, in-house approach for increased speeds in this relatively small Southern African railways is shown to be within reach.

A Solution: For Africa - From Africa

This paper focuses on the application and mechanisms relating to this unique approach, rather than the outcome of the Audit.

Introduction

TransNamib Rail Division has its origin in the erstwhile South African Transport Services (SATS), as the South West African Region. During 1988 TransNamib became an independent Organisation operating under the SATS safety umbrella, and at the time of Namibian Independence, the structure within TransNamib was a "blue-print" of SATS.
Economic pressures and a desire to succeed forced TransNamib to make a direction change in its operations. In retrospect, this was a turning point in TNR's existence, in which they progressively shook themselves free from regulations that restricted their ability to compete in the market place. Although this had the desired positive result, placing TransNamib in an economically competitive position, it also placed them in a precarious state of safety. This had a snow-ball effect, creating a disregard for regulations and a working "from the seat of the pants" situation. This was worsened by the natural attrition of senior staff and the resulting intake of non-railway-experienced personnel to operate in a changing environment.

At this point in time the General Manager of TransNamib Rail Division, initiated an independent rail-safety audit process to place the spotlight back on safety, and to serve as a basis for the establishment of a programme for higher speeds. The underlying requirements are understood to be:

- Improved and entrenched safety
- Scientifically based decision making
- Reduced delivery times
- Higher train speeds (on certain lines)

It was decided that this audit must not follow the path of a typical "first world" approach as first world solutions seldom fit African problems. Many African countries have experienced the "expense" of free hand-outs and the trap of donor-addiction and are rapidly recognising the need for local solutions to their local problems. In securing the services of a suitable consultant/specialist, emphasis was placed on knowledge and experience of the local 1065 mm gauge railway environment and an understanding of train/track dynamics.

Requirements

The requirement was to investigate current train related practices within the Rail Division of TransNamib Limited with emphasis on:

- Train Track Dynamics
- Maintenance Standards and Practices
- Knowledge and skills of key personnel

The proposal was to maximise TransNamib's exposure to safety, identifying critical safety areas and initiate corrective measures in parallel with the audit. This is to be done within a limited budget and in such a way that TransNamib becomes streamlined and flexible in order to meet future challenges and to comply with TransNamib Vision and Mission Statements. For this a unique approach was essential.

Approach

A participative approach was used, wherein BCE played the facilitating role within a pre-selected TransNamib team. Team members represented the various departments/disciplines and were selected for their enthusiasm and ability to positively contribute. BCE spent time with each member examining safety related aspects, identifying areas of concern, educating/training, immediately where possible, and assisted with solutions. Early implementation of solutions are intended to bring about early rectification of problems and hence also early financial returns in the form of savings.
For this the team itself had to be prepared for the task ahead. This includes getting to understand the safety environment, future technologies and how and what to audit. A spin-off of this participative approach is the natural transfer of knowledge, technology and methodologies to all team members and beyond.

First Hurdle

The first hurdle was for the team to come to grips with the full extent of safety in a complex engineering enterprise. This was the single biggest step in the team's learning process.

In a complex engineering system, disciplines and departments are inter-related and dependent on basic technologies. The effective and efficient working of the total system depends on the linking of these technological needs through standards and practices e.g. in the locomotive depot the correct inter-bogie control (IBC) setting actually allows locomotives of heavy axle load to run safely on TNR's light rail with acceptable combined rail stresses. All regulations have their origins, and as long as nothing changes, these tried-and-proven standards and practices are all one needs to operate safely.

In previous years where change was slow, a rigid "military" approach worked well. This was totally inflexible and rules and regulations were explicit leaving no room for interpretation or error. Hence the saying "you're paid to do - not to think!" In this system it was not necessary to understand the origin or cross-discipline effect of the regulation. This produced a compartmentalised mentality and discouraged interest or appreciation of other technologies. Changes invoke fear and from fear, many restrictive illogical regulations grew. Besides creating and perpetuating a dinosaur syndrome, it also deprived people of logic and hence they created their own technical myths. These myths contain a distorted form of logic and erroneous decisions can result in safety critical situations. (This is particularly a problem with drivers.)
In any company of long standing, traces of their history are evident. TNR is no exception. Its compartmentalised and rigid structure is seen to impact on efficiency and flexibility.

Audit Tools

In parallel to the above, the team decided on a certain approach to obtain the best results from the Audit.

"No limitations"

Each person was selected for their area of speciality, however, no limitation must be placed on any member, each having the full right to comment on aspects in other persons areas.

"Zero Blame"

This is an approach in which no blame is attached to an individual causing an incident/accident. Individuals are seen to have a reason for doing what was done and the focus is placed on uncovering and correcting the mechanisms behind these reasons. Blame and hence also punishment are totally excluded and replaced with the need for training.

"To Measure is to Know"
Actual measurements are essential. "I believe ……..." is an auditors worst enemy. Even when one is sure that you know the answer, you still ask Why? Making sure of the persons understanding. Use is made of the "5 Why's" to get to the root of situations.

"Systems Loop"
Apply the systems approach to each element, always ensuring that the loop has been closed viz. Measure - give feed back - reward/restrain - measure again etc. This is done from Company down to individual level.

"Safety Checklist"
A checklist of technical safety aspects was drawn up for the total spectrum of train related practices.

Safety Parameter Audit

The team carried out an audit, each in their own specific field, with emphasis on safety aspects of maintenance standards and practices, knowledge and skills of key personnel, and train/track dynamics technology. This encompassed:

General Safety
Permanent Way
Rolling Stock
Signals/Communication
Traffic
Accident/Incidents/Records

Results

In general safety regulations were in place but not always applied or enforced. The attitude of staff is, however, very positive with a keen desire to improve.

Safety problems, specifically those relating to the implementation of higher speeds, were mainly :

Lack of knowledge

Limited general knowledge of train/track dynamics in [illegible]NR; compartmental outlook; unaware of effects on others; use of specialist contractors of narrow expertise, reluctance to challenge regulations, etc.

Poor discipline/authority
Critical for drivers, train controllers and shunters.

Resistance to Change
Few, but low when combined with technical myths.

Myths
Of particular concern where these affect the judgement in safety critical environments e.g. drivers and train controllers.

Low Stability Fleet
Of 1625 wagons, 1330 are three piece bogies of the Speedbarber design, limiting potential for higher speeds.

Projects

The following are some of the projects that have resulted from this audit, been identified, investigated and/or already initiated, to improve the standard of safety and pave the way for higher speeds:

- Driver and train controller training
- Creation of a Train Dynamics facility
- In-house testing capability for train dynamic related aspects (incorporated in new Train Dynamics Function)
- Conversion of low-stability Speedbarber bogies to Self-Steering bogies
- Higher axle-loads coupled to bogie conversion
- Flange force measurement installation to ensure correct bogie alignment
- Utility vehicle for track condition monitoring and fault rectification
- Tension measurement frame for monitoring continuous welded track and fasteners
- The establishment of a rail safety body to oversee the application of safety philosophy/culture within the management and regulation structures

Conclusion

Train/Track Dynamics Aspects

Track, locomotives, wagons and coaches are generally in good and well maintained condition. Factors influencing safety can be identified and isolated, or in the case of the Spoorbaner bogies, can be converted, thereby making it possible with available infrastructure to approach higher speeds with safety.

Maintenance Standard

In general, standards need to be upgraded and unnecessary or redundant standards to be discarded. With the correct controls and feed back loops installed, some limitations could be relieved to significant financial advantage. These innovations need to be conducted under the controlled umbrella of the Rail Safety Body and Train Dynamics person.

Knowledge and Skills of Key Personnel

This is the area that requires the closest attention.
In key positions, like Train Drivers, Train Controllers and Shunters, critical knowledge, skills and discipline are imperative. This is any Railway Company's single most vulnerable area.
However, TNR Staff in these problem areas, responded positively to the knowledge based approach. Reassuring qualities of enthusiasm and keenness for knowledge and improvement were encountered.

From this it is concluded that with the correct training and required cultural change, operating at higher speeds can safely be done using the existing personnel.

General

During the Audit, the following conclusions and outcomes were experienced at team level :

- The approach used in this audit created a more holistic view between team members, breaking down traditional departmental barriers and creating a better understanding of the influences of regulations and decisions on others. This knowledge-based approach is recommended for TNR.
- This approach lent itself to knowledge assimilation that could be applied directly in the day to day functions yielding immediate benefits.
- In certain areas resistance to change does exist and will need special attention.

- To the best of our knowledge this whole exercise has been self-sustained having run from within the operating budget and created savings greater than the project costs.

A NEW VISION IN AFRICA

TNR - Management's vision and willingness to explore new and innovative approaches has placed them on the threshold of a new era for third world Railways

Appropriate solutions in Africa challenge intellect and create opportunities for technology breakthroughs with application in Africa – and possibly the rest of the World

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The Lord Charles Hotel, Cape Town, South Africa

Paper 9611

Wong Woh Sang

Safety Audit

CURRICULUM VITAE

Wong Woh Sung

Wong Woh Sung is an electrical engineer by training. Having spent 10 years in oil-fired power station projects doing both design and construction phases. Thereafter he spent 5 years with the Mass Rapid Transit Corporation of Singapore for the design and construction for the first Mass Rapid Transit Railway in Singapore where he was responsible for the design and commissioning of the high tension distribution network, DC traction power system and the high speed escalators in the railway.

He subsequently joined the operating company i.e. the Singapore MRT Limited, overseeing one of the maintenance branches for three years. Since 1990, he has headed the Safety Services Department and is responsible in implementing the System Safety Programme Plan including safety audits. The System Safety Programme Plan is the safety management system covering work safety, engineering safety and passenger safety.

Safety Audit

Presented at the
International Railway Safety Seminar 1996
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October 6 - 9, 1996

By:

Wong Woh Sang
Manager Safety Services
Singapore MRT Ltd

1) Introduction

Safety is an important element in most railway operations because trains travelling at high speed usually carry large number of passengers and a major railway accident would not only result in heavy loss to properties but is also very likely to result in loss of many lives and a large number of serious injuries. Such occurrence is not acceptable by the society, government and management of the railway.

A railway is a complex system and it comprises of many engineering disciplines, it carries out various facets of operations, it employs large number and a variety of railway workers and it has many different activities in its life cycle. It is obvious that to achieve safety in a railway system requires a systematic approach. This systematic approach is known as the safety management system (SMS). A SMS comprises many tasks of which one is safety audit.

This paper focuses on issues related to safety audits in a railway environment.

2) The Purpose of Safety Audit

Safety audit is a task in the feedback loop of a safety management system. Generally, the purposes of safety audit are:

a) to verify the implementation and compliance of safety tasks

b) to assess the effectiveness of implementation

c) to evaluate and confirm that the safety tasks meet the safety objectives

3) **The Process of Safety Audit**

An audit process involves two parties, i.e. the auditor and auditee.

From the auditor's point of view, it can be divided into the following four stages:

a) preparation

b) the audit, this makes up of entrance conference, document review, hardware check, interviewing people, evidence review and analysis, exit conference, report writing

c) documentation

d) follow-up action

From the auditee's point of view, the audit process comprises of the following four stages:

a) the entrance conference

b) the audit

c) the exit conference

d) follow-up action.

Therefore, an auditee will only be involved in part of the process that an auditor undertakes.

Here, I would like to focus on the process undertaken by an auditor.

In the preparation stage, the auditor would gather and consider some preliminary information and define the objective and the scope of an audit, identifies auditees and determines the approach. In this phase, the auditor will also need to prepare check lists which will guide the audit process that follows.

In the audit itself, it comprises of entrance conference, document review, interviewing, field observation, hardware examination, record review and consolidation.

The next stage of the audit comprises of exit conference, issuance of final audit report and documentation.

The last stage is to ensure that follow-up action is indeed completed satisfactorily.

The nature of work in these stages are different, and the competency of an auditor is therefore required to cover a wide spectrum of knowledge and skill.

4) **<u>Competency of Auditor</u>**

The competency of a safety auditor can be divided into two main areas, i.e. technical and human aspects.

On the technical aspect, auditors should have adequate knowledge of the discipline that he is going to audit on, has the ability to recognise differences or deviations such as layouts, correct usage, practice, procedures, etc.

On the human aspect, auditors must understand that auditees may not be positive towards audit. They could perceive it as extra work or a fault finding mission. Disputing audit findings is expected; illogical arguments put forward by auditees is also one of the usual scene an auditor is expected to encounter. Therefore, to make progress under such difficult situation, auditor has to be mature, tolerant, diplomatic but firm in dealing with such situation.

It is not difficult to recognise the above requirements. It is also easy to conclude that an experienced railway engineer could meet the requirements in technical competency. However, safety services set-up is usually a small set-up and belongs to support services in a railway organisation. Being a support service, it does not possess hardware of a railway and therefore it could not provide hands-on exposure or learning opportunity for its auditors. Therefore, in order to recruit an auditor meeting the requirements of technical competency, the likely feasible option is to go for internal sourcing from the engineering services. There would be resistance from the supervising manager for releasing his competent engineer. Equally, the engineer would be reluctant to join as auditor which is not a pleasant job and worse, the career prospect of an auditor could not match that of his counterparts in the engineering services. Furthermore, without the hardware, it also could not provide the job satisfaction to a practising engineer. Therefore, there is no surprise that a safety services set-up is unable to attract a technically competent personnel to join and become an auditor.

Regarding the other area of competency, i.e. human aspect, it is common that an engineer who is good in technical work may not be as good in the human aspect. An engineer who is also good in human aspect has plenty more better options than to join safety services.

5) **<u>Independence of Auditor</u>**

The next requirement is obvious and fundamental. It has two aspects, i.e. organisation and individual. It is well understood in finance audits that the audit set up should report to an officer who has no direct involvement in the activity of transaction but has the authority over it. In most cases, he is the CEO or the Chairman of the organisation. In safety audits, there is no established practice and it varies. This is beyond the control of the auditor because the decision on this issue rests with the organisation.

On the individual aspect, an auditor should have no self interest in an audit assignment and has no prejudice. This is well within the control of an individual.

6) Code of Practice of Auditor

Our auditors observe the following:

a) Objectivity (against prejudices)

b) Integrity (against self interest)

c) Competency (against ignorance and haphazard work)

d) Confidentiality (against unnecessary disclosure to third party)

7) External Audit

In financial practice, external audit is usually a legislative requirement to public companies. However for safety management, it is not a common practice to engage external auditor. At this moment, it is also difficult to do so because of the absence of a common standard in safety management system.

For quality system, there exists an ISO 9000 series on quality management system which is certifiable by accredited auditors whose credibility could be recognised worldwide through the ISO set up. There is no such equivalence in safety management at this moment.

Furthermore, a certification in an ISO quality system could be the key for a product to enter and compete in the international market. It has certain commercial value. It is likely that in future, "safety" could well be an added element in the quality of a product. Until such time, external audit on safety management system would remain a good practice of a management in obtaining an independent review for their own consumption.

8) Overlaps between Quality Management System and Safety Management System

There are overlaps between these two management systems and following are the examples:

a process control

o purchase control

o document control

- change control

- training

For some of these, their implementation would require major efforts. Therefore it is best not to duplicate these efforts. Duplication would also cause confusion.

One way to deal with such overlaps would be to leave all the overlap areas into one of the systems, i.e. either the quality management system or the safety management system.

I believe most of you will agree with me at the present moment that there is a well established certifying system on the ISO quality management system. But there is none for safety management system. Therefore, the most logical arrangement would be to leave these overlaps in the quality management system as this will certainly facilitate the ISO certification process.

Having adopted this approach, another problem is whether safety audits should also cover these overlaps. I am of the view that safety audits should also cover these overlaps simply because the focus of quality auditor is different from that of a safety auditor. In addition, in most cases safety is not a declared objective of an ISO system and therefore, the quality auditor could not be held accountable for "safety element" in his audit as it does not exist. On the other hand, a safety auditor could not professionally declare that the safety effort in these overlap areas are satisfactory and acceptable without evidence to support such observation. Therefore, safety audits are clearly needed in these overlap areas.

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Paper 9612

Gerald Churchill

The evaluation of the European Railways safety related certification

CURRICULUM VITAE

Gérald Churchill

Graduate Engineer from "ECOLE SUPERIEURE D'ELECTRICITE" (French Electrical Engineer National School)

Gérald Churchill is in charge of co-ordination, development and technical consistency within the Electrical Equipment and Systems Department. He is the Director's delegate for the management of RATP projects concerning railways, in particular, safety related projects.

Previously, he was responsible for the design of safety systems for all RATP railways and road modes. He managed design projects, safety audits and software safety certification.

After having begun his career in the RATP Rolling Stock Department, he has held positions of responsibility for the design of fixed installations (signalling, ATO, ATC, ATP) and of rolling stock (Metro and Regional Express Rail).

Gérald is the RATP representative in several European Railways Standardisation working groups and is a member for the steering committee for the setting up of the French Railways Certification Agency

The Evolution of the European Railways Safety -Related Certification

by

Gérald Churchill
Executive Manager
Mission of Co-ordination, Development and Technical Consistency
Department of Electrical Equipment and Systems
RATP - France

1. The Two Approaches that Guarantee Railway Safety

One of the characteristic features of railways since their creation has been that they were owned by big national companies attached to the regulatory authorities. This is how such big European networks as SNCF, BR or DB are born.

In that context, the Government imposes some rules in the form of acts and decrees to these companies, in particular for safety. This is the regulatory approach.

However, the specific statutes of railway authorities have been accompanied by a very important delegation of the Government. Thus, in France, SNCF and RATP, the only operators of structured networks, have developed their own rules internally.

This approach on companies initiative is an approach of the voluntary type.

Railway safety is therefore obtained by a combination of both of these approaches and railways history shows that it was justified.

2. Factors of Evolution

Many factors have modified the balance between the regulatory approach and the voluntary one since the end of the eighties. They are mainly related to the European construction and the opening of the single market, to the international crisis and to the almost general privatisation of the railway networks.

Hence, for the different governments of European Union, the necessity to review their organisation in order that the constraints brought about by this evolution shall not decrease the present level of safety.

This presentation is restricting to the European aspect and to the railway safety-related systems and equipment certification.

The first part tackles the new European reference regulation and its consequences, then the voluntary reference standards.

Lastly, my final part will highlight particularly the French situation.

3. The New European Regulation

• 3.1 The European Directives

In 1957, the countries who were signatories to the Treaty of Rome affirmed their will to build a large European market. It rapidly became obvious that this creation assumed the harmonisation of European regulations. This was the object of the Single European Act (1986) and this is the major objective of the New Approach (1985), completed by the Global (1989) and Modular (1993) Approaches which are both explained hereafter.

The New Approach imposes that the European directives restrict to general requirements, which are called essential requirements, and do not include any technical specifications.

The Global and Modular Approaches complete the new approach system by setting the direction of the European certification and testing policy. This policy is supported by a number of modules ranked from the simple conformity notification to the complex certification process.

Within the framework of the New Approach, an independent and competent body is entrusted the verification of essential requirement. The certificates issued by such a notified body are valid all over the European Union. They are cross-accepted implicitly.

• 3.2 European Railways Directives

Until now, only a few European directives affected railways and none directly. Such a fact will change when the directive on the interoperability of European high speed networks is implemented in 1998. Moreover, the measures of this directives are more likely to be extended to the other modes of railway transport.

Although it is not a pure 'new approach' directive (for example, with reference to EC marking), the directive on the interoperability of European high speed networks uses some tools of the new approach such as the vital requirements or the notified bodies.

- 3.3 Links between Regulatory and Voluntary Approaches

The new approach precludes technical specifications. These are described in the European standards named harmonised standards. Standards which come within the voluntary approach take on a regulatory nature when they are referred by a directive or documents annexed to directives such as Interoperability Technical Specifications.

4. The Voluntary Field

- 4.1 The European Normative Process

Faced with the lack of European Railways standards, and taking into account the evolution of the regulation, the EC commission has mandated CEN and CENELEC, European standardisation bodies, to create the European railways standards frame.

TC256 from CEN and TC9X from CENELEC have been entrusted with this task, co-ordinated by the JPC-R (Joint Programming Committee-Rail).

About 70 working groups, bringing together more than 300 experts, are given the responsibility of making standards: about 150 of them are at the moment in the process of being drafted (the first standards begin to be issued).

Amongst these, 3 standards are worth considering because the process for the certification of railway systems and equipment is going to depend on them, and therefore they will serve as an input for the making up of regulatory conformity certificates.

These standards are described briefly hereafter.

- 4.2 The Standard EN50126

prEN50126 is a major top document which does not state the process of approval but gives the general frame for the development of railways systems in respect with their Reliability, Availability, Maintainability and Safety Requirements.

This standard specifies a development life cycle which describes the tasks that need to be performed in order to have a strict top-down RAMS management process and therefore necessary to obtain the approval. It gives also a number of documents which have to be produced all along this process and which are mandatory for the make up of the approval documentation. Particularly, a document called "Safety Case" groups all the safety related documentation including for example the Safety Plan

There are three types of Safety Cases depending on the level of approval to be obtained:

- A generic product safety case (for example a vital computer)
- A generic application safety case, for the generic product used in a certain type of application (for example, this computer used in ATP systems)
- A specific application safety case (for example this computer used in the ATP operated on the LAR line in Hong Kong)

- 4.3 The Standard EN50129

prEN50129 addresses electronic equipment for signalling. Its purpose is to specify the content of the Safety Cases in this specific context. Therefore it derives the requirements of prEN50126 and adapt them for the development of railways signalling equipment.

At the level of a Line Replaceable Unit, this standard uses the concept of Safety Integrity Level ranged from 1 (low confidence in safety) to 4 (highest confidence, for critical equipment only). Safety integrity is comprised of two components, systematic Failure Integrity - which relates to unpredictable hazardous faults usually caused by human errors - and random Failure Integrity - which relates to predictable hazardous faults due to the finite reliability of hardware components. The SIL make the link between the qualitative measures (as quality management), that need to be enforced to cope with the systematic failures, and the quantified safety targets.

Thus, the standard proposes target figures, methods and tools which when put together should lead to the achievement of a certain level of confidence in the safety performances of a given product. The SIL should only be defined at a low level of design in order that the associated approval document be meaningful with regard to cross-acceptance.

- 4.4 The Standard EN50128

prEN50128 is focused on software aspects of signalling equipment. It uses also the concept of SIL since there are only systematic faults in that specific case of software and therefore SIL allow to define a qualitative appreciation of the level of safety. As prEN50129, this standard applies the requirements contained in prEN50126 to the development of railways signalling software.

Moreover, it defines methods and tools to achieve a given Safety Integrity Level for the software.

- 4.5 Agreements of Cross-Acceptance

Contrary to the certificates issued by a notified body within the regulatory framework, the compliance with non harmonised standards is not systematically cross accepted.
But the signing of cross-acceptance agreements is encouraged by the global approach, within the frame of EOTC (European Organisation of Testing and Certification).

5. The Evolution in France

- **5.1 The Present Situation**

As stated previously in the introduction, French certification is nowadays performed directly by SNCF and RATP. Rules and regulations are very few and very general.

The government and the regional authorities give the authorisations to put the main railway systems into service, but they are based very often on the certificates issued by the railway authorities themselves.

However, the government or the regional authorities can rely, in case of any doubt, on a research body, INRETS (National Institute of Research in Transport and Safety), which is the only entity independent from the French operators with knowledge in the field of railways.

Besides, the role of INRETS as far as certification is concerned has strengthened for the last years since many small operators are running local systems as VAL or tramways and cannot afford an internal structure of certification.

- 5.2 The Directions

French present situation is not compatible with the new European regulation. So the main parties involved in French railways have started thinking about the possible evolution since the end of 1994.

Comparisons with our partners in Europe, in the railways field and in many other industrial fields, highlighted different solutions, from the government itself taking the responsibility of the certification activities (like civil aviation and like the option retained in Germany with the setting up of EBA (EisenBahn-BundesAmt), to the total privatisation as it is planned in Great Britain.

The study had to take French specificity's into account. The first one is the government commitment to public services as far as France is today the only European state which is not intending to privatise national railways. The second one is the will of the government to disengage from administrative processes.

After analyses of the various structures, the statutes of inter-professional association have been proposed. Their features, in the sense of French laws, meet both the new regulation requirements and the specificity's that have been expressed :

- *non profit-making body: respect of one of the founding principles of public service*
- *joint body: guarantee of impartiality and competence*
- *Independent body: respect of the regulation*

At the moment, works are being achieved in order to specify the way this body called ACF (railway Certification Agency) will work. Its statues will be registered before the end of 1996.

ACF should be founded by the main French railways actors : SNCF, RATP, INRETS and FIF (Railway Industries Federation). Its structure reminds of AFAQ one (French Association for Quality Assurance), the only French body which is authorised to issue ISO9000 certificates.

5 Sectoral committees should be set up under the Board of Directors Authority. 4 of them would correspond to the ITS (control, energy supply, infrastructures, rolling stock), and one would be dedicated to the other fields. They should all be made up of volunteers from the founding societies. An assessor co-ordinator would take the responsibility of each approval case. He would work in collaboration with competent experts and laboratories and put the final case to the sectoral committee.

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Malin Kotake

Risk Evaluation and Risk Assessment at the Swedish National Rail Administration

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CURRICULUM VITAE

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She works at Banverkets Head office at the Planning department with safety and risks arising from train traffic, especially risks associated with the transport of dangerous goods and risks at road/rail level crossings. The work includes method development and supporting Banverket's regional offices in their work with risk assessment and risk evaluation.

At present, Malin Kotake is project leader for the development of a handbook for risk assessment in connection with the planning of railways. She is also Banverket's representative in a National Risk Delegation dealing with risk co-ordination.

Before working at Banverket she worked at the National Board of Housing with the development of municipal risk assessment for physical planning.

Risk Evaluation And Risk Assessment at the Swedish National Rail Administration (Bankverket)

by

Malin Kotake
Planning Division
Swedish National Rail Administration (Banverket)

Banverket - Facts and Figures:

Infrastructure:

Track length total	:	10 900 km
Double track	:	1400 km
Electrified	:	7350 km
Number of level crossings		11 800 km
Tunnels		

120 st, total length 25 kilometres, longest [illegible] km

Traffic:

Freight traffic	:	19 000 million tonne-km
Passenger traffic	:	6 200 million passenger-km

Staff:

Banverket total		6 700 persons
Head Office	:	400 persons

The Transport Policy Resolution

In 1988 the Swedish Parliament decided on a railway reform which included the upgrading of the Swedish Railway system. The 10 year investment plan 1994-2003, which was worked out, included projects for 32 billion SEK (US$ [illegible]).

High safety was together with reduced travel time, lower costs, increased comfort and improved environment one of the important goals formulated in this plan.

In the railway reform of 1988, the responsibility for the railway infrastructure was transferred from SJ (the Swedish State Railways) to the newly founded National Rail Administration (Banverket). The responsibilities of Banverket were to be the operation, maintenance, planning and capital financing of the State owned rail network. SJ was turned into a train operator acting on commercial basis.

The government issued a special regulation on Banverkets planning process which made clear that resources for maintenance and investments were to be used in projects yielding the greatest possible socio economic benefits. The socio-economic approach were also to be used in the risk evaluation process both to decide if risk reducing measures were socio-economically profitable or not and to give priority to different measures.

Risk/Accident Evaluation according to the Socio-economic Model

The socio-economic calculation is based on the fact that there is a socio-economic cost in case of an accident. The cost includes both material costs and costs tied to injured and killed persons.
Measures which reduces material damages and the number of injured and killed can be regarded as a socio-economic saving. If the cost of the measure is lower than the calculated accident cost the measure can be justified according to the socio-economic evaluation.

The cost tied to injured and killed persons include production losses, hospital care costs and human value or risk value as it is also called. The risk value is the amount that individuals are willing to pay beside the material cost in order to reduce the risk of an accident with grave consequences such as deaths, serious injuries etc. The risk value is the largest single cost component in the cost tied to injured and killed. The values are congruent with those used in the road sector.

The risk evaluation is often the most difficult part of the risk analysis since it is the base for deciding weather a certain risk is acceptable or not. In Sweden, no national established risk acceptance criteria's exist. The discussion concerning "acceptable risk level" can in many situations be controversial since it includes emotional as well as moral aspects.

When evaluation risks and different measures it is important to look at the system as a whole to avoid sub-optimisation. Risk reducing measures on both infrastructure and wagons as well as in the environment surrounding the railway must be considered. Banverket distinguish between measures designed to prevent incidents and measures designed to reduce the impact of incidents.

Transferring traffic and improving safety at road/rail crossings

Accident statistics are analysed and the various risks in the railway system were identified, quantified and evaluated in order to determine what safety measures would be the most effective.

Since financial resources are limited it is important to ensure that the available resources are optimally used. The safety standard should correspond reasonably on new and existing lines as well as on different objects and sections within the railway.

The risk assessment made showed that the largest gains of improved safety are obtained by transferring traffic from road to rail and by eliminating or improving road/rail level crossings.

The background to this is that safety for passengers in public ground transportation in Sweden is very high. In railway traffic on average 2.1 passengers are killed annually during 1985-1994 which is about 0.25 killed per 1 000 million passenger / kilometre.
This may be compared with the road sector where during the years 1984-86, 6 persons per 1 000 million passenger / kilometre were killed annually. Consequently the transferring of passengers from road to rail make a large traffic safety gain.

Accidents at road/rail level crossings are the most common type of accident at train movement in the railway sector in Sweden. It is also the type of accident which leads to the largest number of killed and injured. During the years 1983-1992, 251 persons were killed in accidents at level crossings. This can be compared with e.g. collisions and derailments, 15 killed, and accidents with dangerous goods, 0 killed. It should be noted that 98% of the persons killed at level crossings are road users and not rail passengers.

Banverket has the last years focused its safety work on eliminating and improving level crossings. Between the years 1989 and 1995, the number level crossings has decreased from 15 800 to 10 800. This has resulted in a decrease in number of accidents from on average 70 per year at the end of the 1980's to on average 50 per year the last three years. Banverket has worked out a model where its possible to predict the number of accidents, consequences and costs in different types of crossings. The model includes parameters such as type of crossing, train speed and train and road traffic volumes.

Beside these measures which for safety reasons can be socio-economically motivated the upgrading of the railway system itself leads to a higher safety standard. Better tracks and sleepers, the installation of detectors and the improvement of the signal system leads to a reduction of the occurrence of initiating faults.

A number of serious derailments and collisions at the end of the 1970's led to the introduction of ATC (Automatic Train Control) on the Swedish railways. ATC is an advanced safety system for controlling train speed. The effects of ATC are shown in a significant decrease of collisions and derailments.

Improving the Risk Value

Banverket is co-financing a research project aiming at improving the risk value. More detailed knowledge about the evaluation of accidents with different degrees of seriousness is essential. The aversion to one accident with large consequences seems to be bigger than for many small accidents with the same total extent of damage. The amount of control over the situation and the degree of voluntaries are other factors which influence the risk evaluation. Today Banverket uses the same value for every human life saved.

Method for Risk Analysis of the Transportation of Hazardous Materials

During several years the risks arising from the transportation of dangerous substances has been in focus. This despite the fact that during the last 50 years no person in Sweden has been injured or killed due to the transportation of dangerous goods by rail. However in case of an accident the consequences may be severe.

The National Road Administration, Banverket, SJ among others co-financed a research project dealing with risks from the transport of hazardous materials on road and railroad. The aim of the project was to develop a method for

- estimating the number of accidents which can be expected to occur
- estimating the probabilities of a number of possible event sequences/scenarios and their consequences in case of an accident and
- calculating the expected economic costs of an accident

Possible measures to reduce risks, either by decreasing the probability of an accident or by mitigating the consequences of an already occurred accident, are discussed in all four parts of the project.

One important result is that economic costs of accidents which could be expected due to the transportation of hazardous materials were found to be comparatively small. The cost effectiveness analyses showed that precautionary measures such as establishment of safety areas can not be justified on the grounds of reduced costs of accidents employing an ordinary evaluation of personal injuries based on traffic economics.

Another result is that it is not justifiably possible to say that rail is safer than road or vice versa. The most suitable mode of transport must be determined for each specific transportation task.

Ongoing Studies

Beside the already mentioned study on improving the risk value Banverket are working on a hand book for risk analyses in connection with the new construction/planning of railways. In this handbook the experiences from the work so far with risk assessment and risk evaluation will be gathered.

In Sweden the planning of new railway lines are regulated in "The Railway Planning Act". According to this Act an Environmental Impact Assessment are to be made when making a "Railway Plan". There are no corresponding legislative demands concerning risk assessments. Despite this fact risk assessments are often made in connection with larger railway projects.

The extensive building of new railway lines also include the building of new tunnels. In a few years there will be over 150 tunnels with a total length of 70 km (longest 8 km). An ongoing study is aiming at improving the method for analysing and evaluating risks in tunnels. The criterion is that it should be as safe to travel in tunnels as on the rest of the railway net.

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Johan de Villiers

Risk Profiling a Railway Line: The Spoornet Experience

CURRICULUM VITAE

Johan de Villiers

Johan graduated with the degrees B.Sc. B.Eng. (Mechanical) at the University of Stellenbosch in 1995

He started his engineering career with the South African Railways and Harbours immediately after graduation and worked in various divisions of the railway and harbours organisation.

Johan gained experience in the maintenance of Rolling Stock and the manufacture of new rolling stock and of specialised rail infrastructure such as the high speed turnouts used on the coal export line. He also worked as an engineer in the foundry and the harbours in the design and building of new harbour craft

He experienced the change from a Government managed railways to a fully commercial entity while working as a Manager in Train Operations and in Risk Management

Presently he is in the fortunate position to put both his Risk Management and Train Operations experience into practice with the instruction to establish a new department within Operating called Operating (RISK).

RISK PROFILING A RAILWAY LINE: THE SPOORNET EXPERIENCE.

INTRODUCTION (See FIG. 1)

The traditional approach to risk profiling is to place the spotlight on catastrophic losses. With this view it is accepted that the high frequency low intensity losses are well known, clearly identified and under control.

Mindful of the definition that a risk profile describes the relationship between the frequency at which losses can occur and the consequences (i.e. severity) that may be expected if these losses do realise, a process was developed, using the principles of risk profiling, to make the hidden losses - that are so readily accepted as unavoidable - visible.

The process was to use accepted risk profiling principles, adapt and apply them in order to determine the influence of pure risk on the business. This means that a wholistic picture had to be drawn to enable the visualisation of the matrix effect of incidents (even though they may not have been identified as an incident) on the core business.

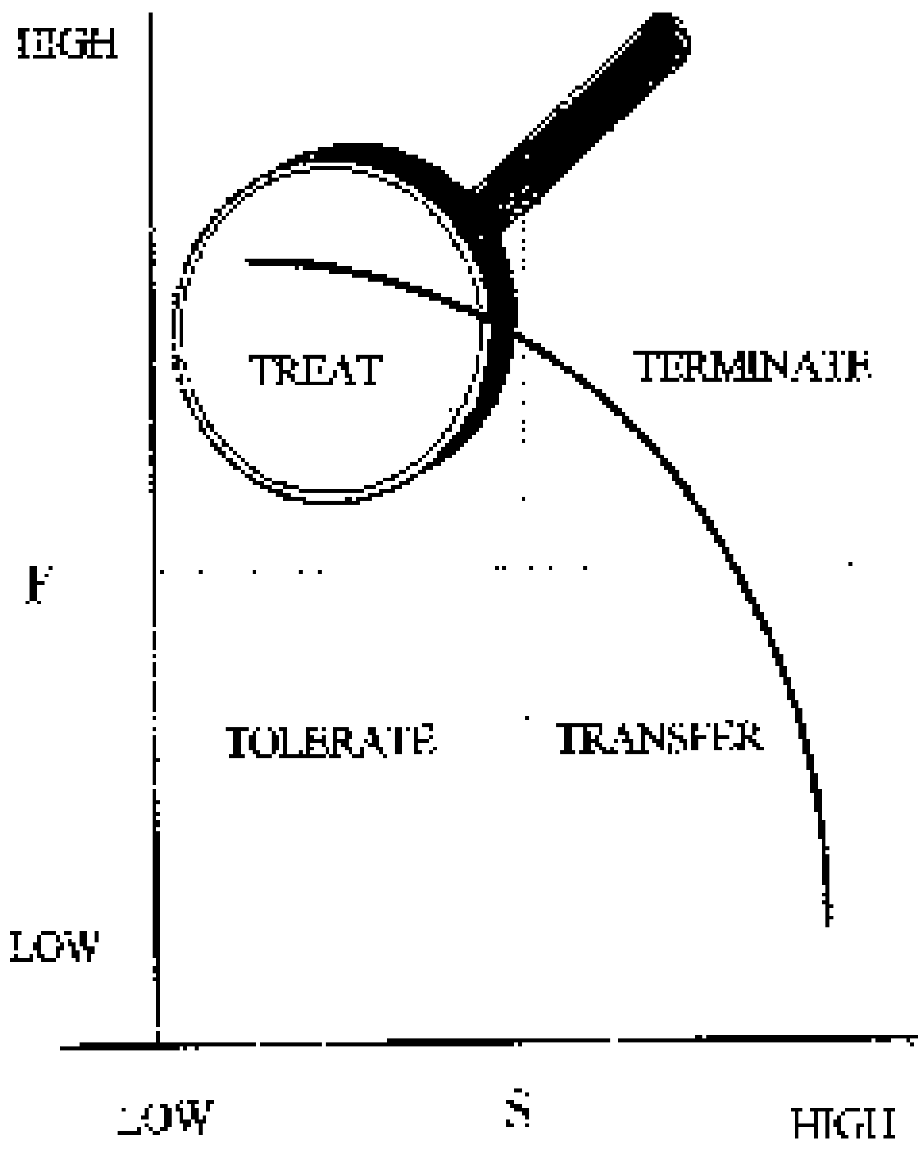
The normal risk distribution curve can be divided into four sections (the four-T's) namely;

- the **TOLERATE** sector that denotes risks that do not warrant more effort and finance to improve management thereof. Monitoring the situation is the crucial management activity.

- the **TRANSFER** area that typically describes the field where catastrophic failures can be expected and where the manager will seek survival support through the purchasing of insurance.

- any activity that measures in the **TERMINATE** zone should receive immediate management attention and if improving the situation through the improvement of controls seems inevitable, consideration to terminate the activity, should be given. In this quadrant the frequency of losses and the realised (or expected) consequences are of such a nature that survival is regularly at stake.

Figure 1



F = Frequency
S = Severity (consequence)

* even though all the segments of the four-T's have received attention in the Spoornet risk profile study this presentation will zoom in on the detailed analysis of the THREAT area. This is the area where both management and supervisory "good practice" is crucial. The approach was that the quality of work can be improved by exposing the activities and influences and then concentrating efforts on the right procedures etc.

THE PROCESS (See FIG.2)

Profiling the "THREAT" area was developed along the following route:

* identify the most exposed and/or vulnerable activities. These were called "soft spots". This was done by means of entity/process profiles.

* identify through the study of historical data, areas where losses occur and the frequency of occurrence. These were named "**hot spots**". Hot spot identification was done by the development of a binary event tree (the binary event tree had either a "yes" or a "no" answer to every question). When a hot spot and a soft spot overlap it is interpreted as a looming catastrophe and immediate attention warranted.

* the results of both hot spot and soft spot area studies were verified by discussions with the operational personnel concerned. The objective : to confirm the accuracy of the information.

* research was done to establish control mechanisms through which the hot and soft spots can be managed or management thereof improved,

  and

* conclusions and recommendations were formulated.

In some instances it was discovered that the hot spots could not be clearly identified while in other situations control measures were either absent or not clearly identifiable. The judgement of knowledgeable employees from different disciplines, to enable the formulation of practical solutions proved to be of utmost importance.

Figure 2

RISK PROFILING

IDENTIFY THE "SOFT SPOTS"
(ENTITY PROFILE)

↓

IDENTIFY THE "HOT SPOTS".
(BINARY EVENT TREE)

↓

VERIFY AND DISCUSS/CONFIRM

↓

RESEARCH CONTROL MECHANISIMS/
SYSTEMS

↓

PERSONAL JUDGEMENT

↓

CONCLUSIONS

↓

RECOMMENDATIONS

THE SOFT SPOTS (See FIG. 3 and FIG.4).

A wholistic picture of the soft spots was created in two steps.

STEP ONE.

The first step was to view the final product (output) of the ultimate process (running a train) from the asset utilisation perspective.

- after choosing a physical / geographical "cut"[1] to place under the spotlight, all the fixed assets available to produce the output over the "cut" were written in a block in the centre of the page.
  [1] A "cut" is a selected physical section of the railway line that will be examined, evaluated and profiled.

  Typical fixed assets listed were :

  the perway
  electrical overhead power supply equipment
  signals
  communication hardware (i.e. relay towers etc.)
  on-rail equipment (i.e. hot axle boxes & dragging equipment detectors)
  bridges, culverts, cuttings etc.

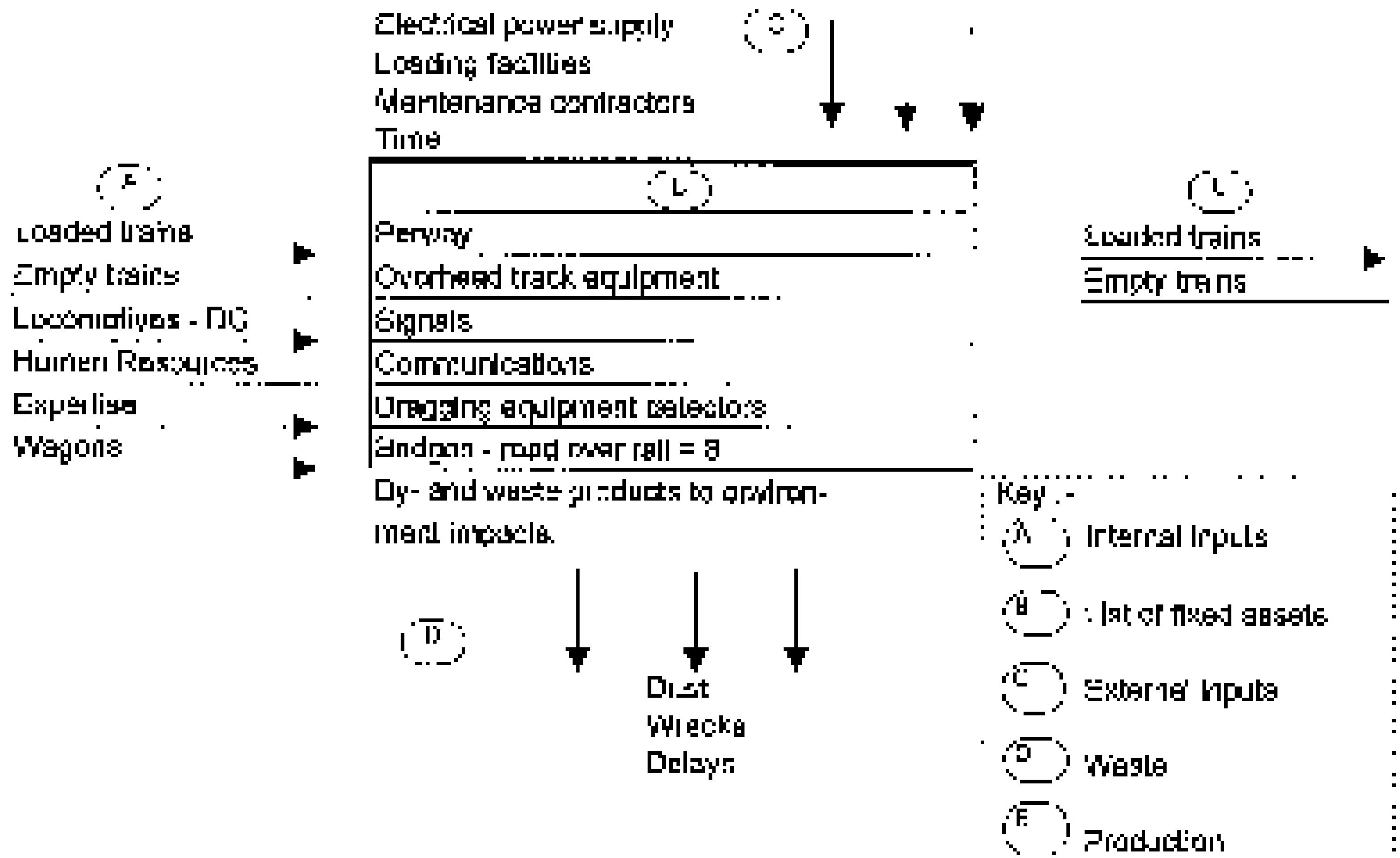
- identify and list the "internal" inputs that will have an impact on the infrastructure in order to produce the output.

  Typical "internal" inputs were.

  tractive effort (locomotives)
  human resources (employees)
  expertise
  wagons.
  etc.

Figure 3

Entity Profile



- list the external inputs. These were the resources that are bought or contracted into the process under scrutiny.

  Examples are:

  electrical power supply
  maintenance contractors
  time
  hired loading facilities
  etc.

- write down the waste / by products that are produced during the operation.

  Examples:

  dust
  noise
  delays (wasted time) and
  wreckage's (from accidents)

STEP TWO.

The next step is to do a risk assessment by carefully analysing and evaluating every element identified and listed in the entity/process profile. A physical examination and inspection of the entire route is absolutely essential for the successfull handling of step two.

To assist the process the elements that could or could not be influenced by a failure of the element was catagorized as follows:

- factors that can negatively influence the population living near the railway line were considered and evaluated under the heading **"SOCIETY"**.

- factors concerning the people (employees and contractors) that work for the railway on the "out" under consideration was considered under the heading **"EMPLOYEES"**

- all assets both, fixed and movable, were evaluated under **"ASSETS"**.

- third party interests are under **"LIABILITY"**.

Figure 4

Risk Assessment

Macro / Broad

Element	Criticality to :- Society 1	Society 2	Society 3	Employees 1	Employees 2	Employees 3	Assets 1	Assets 2	Assets 3	Liability 1	Liability 2	Liability 3	• Business (Market Image) 1	• Business (Market Image) 2	• Business (Market Image) 3	• PURE FINANCIAL (REVENUE) 1	• PURE FINANCIAL (REVENUE) 2	• PURE FINANCIAL (REVENUE) 3	• Pure financial 1	• Pure financial 2	• Pure financial 3	Process 1	Process 2	Process 3	Notes
• Loaded Trains	X																								Very sparsely populated.
				X																					No adverse working conditions.
							X																		Alternatives available.
														X											Business must be managed.
																		(X)							Loaded train critical to business.
																					(X)				Main source of income.
																							X		Limited alternatives.

X

1 Negligible
2 Moderate
3 Critical

- the market related matters such as loss / potential loss of market, image etc. were categorised "**BUSINESS**".

- the availability or unavailability of spare or alternative capacity was considered under "**CAPITAL**".

- "**PURE FINANCIAL**" contained those elements that could be critical to the income statement

  and

- in the "**PROCESS**" column considerations were based on those factors that impacted on the core processes

A few examples of the type of questions that were asked are:

ASSETS:

How critical is the particular asset for the process?
Possible reasons for a "non critical" answer.
- alternatives available
- spare capacity
- easy to replace
- etc.

SOCIETY:

If control of the process fails will the effect on the public be serious?
Factors to consider:
- population density
- type of product
- type of incident that can occur
- political environment
- social activities in the vicinity
- etc

A criticality picture emerged as the process of assessing every identified element (refer to the entity profile) proceeded and elements were classified critical or not critical measured against the above type of criteria.

In order to also consider the possibility of elements changing from non critical to critical it was decided to have a third category of "moderate" criticality. As a refinement of the process, consideration was given to the influences that may swing moderate to critical (aggravating factors). If the aggravating factors were considered an added threat the element was redefined as critical. This action obviates the possibility of underestimating the critical factors

The points on the risk assessment matrix that became critical were circled and identified as "**SOFT SPOTS**".

The mere fact that the soft spot identification and evaluation process is done systematically and logically very often provides enough information to be able to address the management procedures and to develop remedial and performance improvement actions.

THE HOT SPOTS. (See FIG. 5)

Hot spots are identified by systematically analysing historical data.

This was done through the development of a binary event tree. The analysis was conducted from a business risk view point and in order to distinguish the sales part of railway business from "time- and place value" - added and to enable the modelling of every individual vehicle (wagon), a production unit was defined.

A production unit is defined as : A WAGON TRAVERSING THE ENTIRE SCHEDULED LINK (ROUTE) WITHIN THE SCHEDULED TIME.

From this definition the top event was defined as:

TOP EVENT:

ANY DEVIATION, IRRESPECTIVE OF REASON, FROM THE SCHEDULED ROUTE AND TIME. (Time, in units of 30 minutes was used as the measurement).

To highlight the implications of these definitions a few examples are quoted:

- if one wagon on a load of 100 wagons fails and the full load is delayed and arrives one hour late at the destination then the top event was 1 x 100 = 100 production hours lost.

Figure 5

PRODUCTION UNIT :-

A wagon traversing the entire scheduled line (route) within the scheduled time.

TOP EVENT :-

Any deviation, irrespective of reason, from the scheduled route and time.

- the same scenario as described above but the load arrives at the destination on the scheduled time. It is considered that the control and corrective measures operated satisfactorily and there was no top event
- as described previously the entire railwayline was divided into "cuts". In the case of a run - through section the departure point and time was taken at the point of entry into the section and the destination point and time at the point of exit (leaving) the cut

THE BINARY EVENT TREE (See FIG.6)

The binary event tree also supplied a reason that can explain every top event. Reasons were only allocated after the careful and detailed scrutiny of all the available documentation and other information.

- The documents that were studied included all log sheets and log books.
  All on-train documents such as train delay statements
  technical and
  operational documents (train compilation and train brake certificates,
  drivers works orders etc)
  All train arrangements and operating records / files.

  and

  Individual incident files and statistical records.

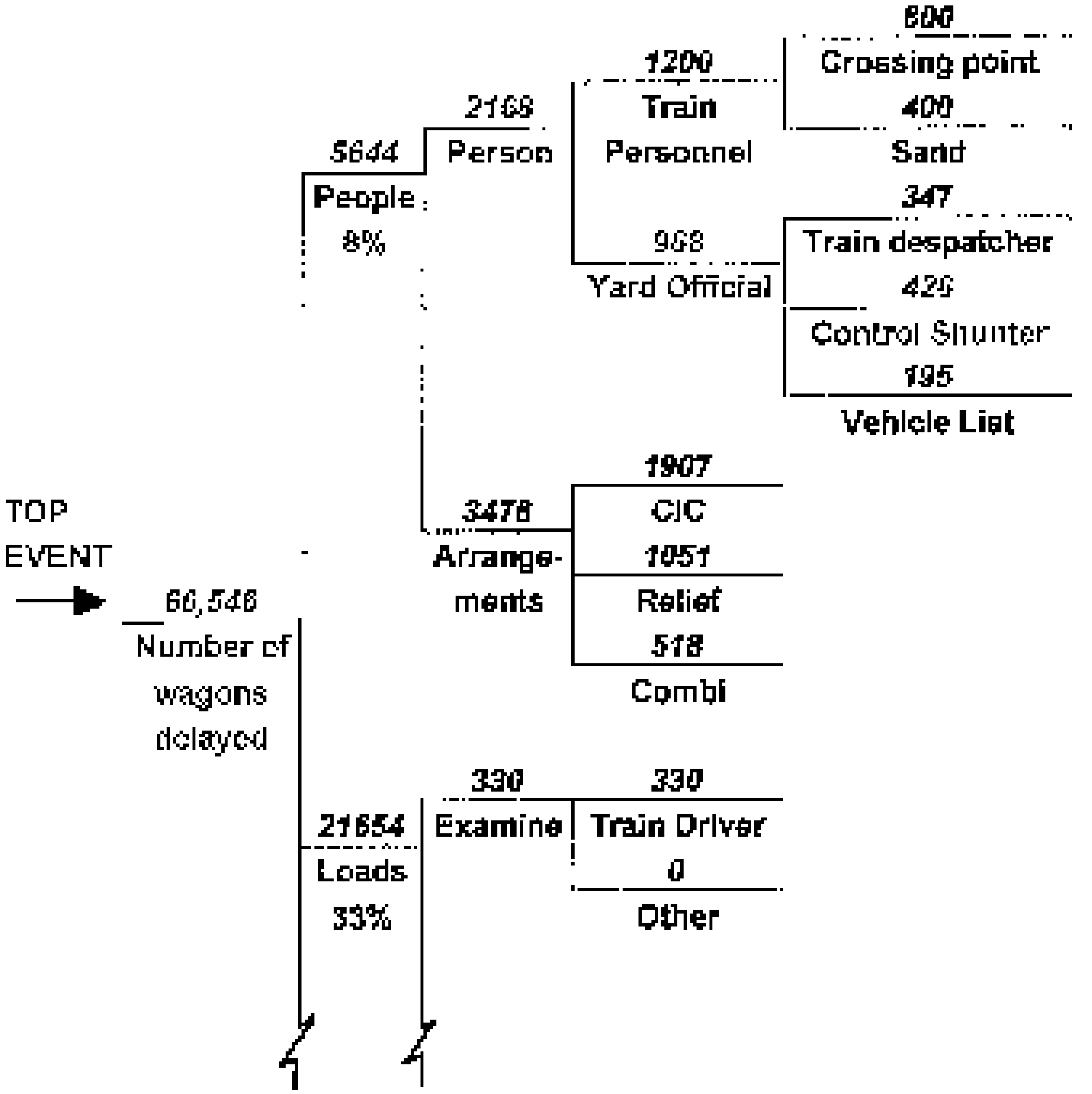
The development of a binary event tree depends on the prerequisite that all questions must be structured such that the answer can only be a "yes" or a "no".

Example:

- can the top event be ascribed to a human "failure"? If "yes" log the time allocated. A human top event must be clearly distinguished from technical, environmental or poor system arrangements.

Figure 6

BINARY EVENT TREE



- the second phase development is to ask: if "people" are involved can it be due to the failure of the individual ? If "yes" - log. Possibilities are, failure to arrive for work, an accident en route to work, felt ill etc.

- the third phase is to ask: If the individual is responsible, can it be due to what basic cause ? (Example. lack of, wrong, to long ago etc. Illustration. Driver cannot continue with train due expiary of roadknowledge past crossing point). Again log if "Yes".

In order to also establish the consequences of all the "yes" logs the time allocations were divided into time units of 30 minutes per unit. i.e. all top events within one to thirty minutes in the "units" of 30-minutes, all events from 31 minutes to 60 minutes into the next unit, etc. (See Fig.7)

The units are.

1 to 30 minutes
31 to 60 minutes
61 to 90 minutes
91 to 120 minutes
etc.

The final step in this analysis is to calculate the frequency of the occurrences. Frequency is expressed as a ratio of the number of times that any of the top event failures realised vs the total number of activities that occurred.

Illustration : If two x 30-minute top events occurred on ten trains each consisting of one hundred wagons during a period that one hundred trains of one hundred wagons each ran the ratio is :

number of events (i.e. 2) times number of production units influenced
(2 * 100 = 200)
divided by the total production possible (100 * 100 = 10000) therefor
0,02

The closer this calculated value comes to one, the hotter the spot becomes. One will in fact say that every time the activity takes place a loss will occur. A figure 0.000001 says that, on average, every millionth repetition of an activity there might result in a loss.

Figure 7

THE "HOT SPOTS"

SUBDIVIDE THE PRODUCTION HOURS
LOST IN UNITS OF ½ HOURS LOST

TOP EVENT
½ / 1 / 1½ / 2 /ETC.

INFRA
½ / 1 / 1½ / 2 / ETC.

ROLLING STOCK
½ / 1 / 1½ / 2 / ETC.

HUMAN RESOURCES
½ / 1 / 1½ / 2 / ETC.

From these calculated figures it is possible to draw risk distribution curves. Superimposing the graphs drawn for the different top event classifications the final graphical picture details the relative influence of each roleplayer. **(See Fig.8)**.

With this information at hand it is fairly easy to decide on performance standards and to specify the required output. The difference between the standard and the output (as represented by the graph) is the shaded area on **Fig.8**.

CONTROL MEASURES

The study of the control measures is a completely different exercise that should be undertaken. It is however not the intention to discuss it as part of this presentation.

CONCLUSIONS (See Fig.9)

POSITIVE

- The results of the study is based on historical facts. Factual information and conclusions are devoid of the emotional implications of opinions and deductions. It is therefore more acceptable and less likely to be disputed.

- Generalities are eliminated. The factual results are focused, clear and enables the setting of goals and standards.

- The measurement is repeatable. It is possible to measure precisely the same elements and factors in future. By changing a single element, even if it is not a directly measurable element, the influence of the element is measurable in the end result.

- As a tool the result can be used in the support of numerous other projects. For instance : decisions on capital investment can be greatly improved if factors such as the possible elimination of hazards or the creation of new hazards can, to a fair degree of accuracy, be foreseen.

NEGATIVE.

- The process is labour intensive and time consuming. Therefore expensive.

Figure 8

GRAPHICAL DISPLAY

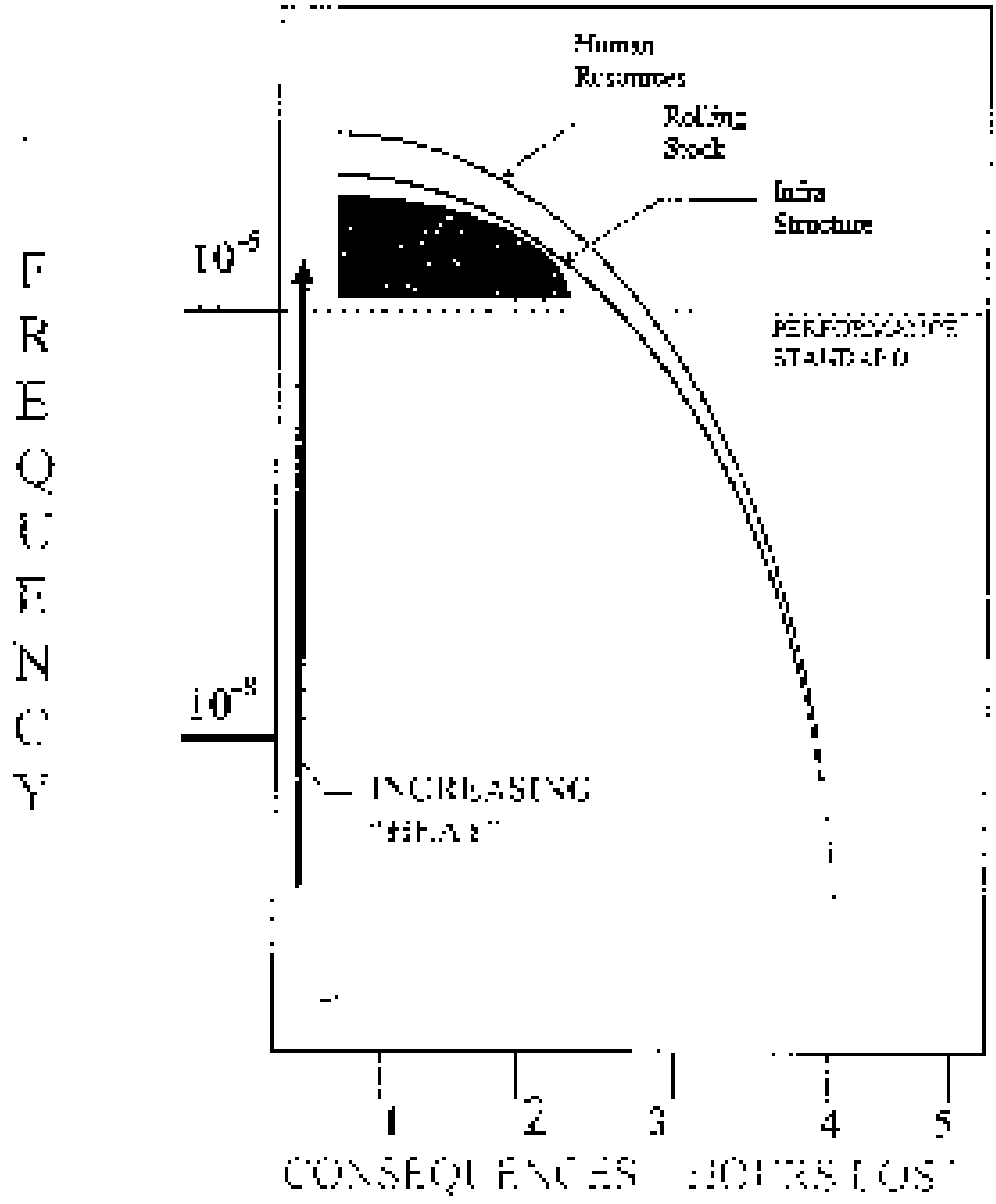


Figure 9

CONCLUSIONS

Positive :-

* Facts not Emotions
* Generalities eliminated
* Repeatable
* Support other projects (i.e. Capital)

Negative :-

* Labour Intensive

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Paper 9615

Loh Chow Kuang

Project Safety Review: A life-cycle approach to safety management

CURRICULUM VITAE

Loh Chow Kuang

MSc(Transport Eng.), B.Eng.(Civil), MCIT

Mr Loh Chow Kuang is the manager for Safety Assurance of the Land Transport Authority, Singapore. He received his masters degree in Transport Engineering from the University of Newcastle-upon-Tyne in the United Kingdom, and bachelor degree in Civil Engineering from the National University of Singapore.

He has authored/co-authored four papers on transportation subjects and has more than 10 years of professional experience in rail and bus planning and operations, comprehensive transportation studies, travel demand modelling, traffic management and transport policy formulation.

He is a Chartered Member of the Chartered Institute of Transport and a Board Member of the CIT Singapore Council. Mr Loh is currently leading a major project to establish a safety management system for the Land Transport Authority's rail and road projects.

PROJECT SAFETY REVIEW - A LIFE-CYCLE APPROACH TO SAFETY MANAGEMENT

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Manager, Safety Assurance

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ABSTRACT

The Land Transport Authority (LTA) is responsible for planning, designing, building, operating and maintaining rapid transit systems in Singapore, as well as to regulate the operation of these systems which cover both mass rapid transit and light rail transit. To achieve a high level of safety in the development and operation of rail systems in support of its vision for a world class transport system, LTA has recently embarked on a major project to develop an integrated Safety Management System, known as Project Safety Review. This is to facilitate systematic assurance of safety at various stages of rail projects throughout the projects' life-cycle, from inception through implementation till disposal. This paper provides the background of the SMS development and outlines the proposed framework of safety regulation, safety validation and other management processes for safety assurance.

INTRODUCTION

Roles of The Land Transport Authority

The Land Transport Authority (LTA) is a Statutory Board formed by the Singapore Government on 1 September 1995 by merging all the public sector entities in charge of transport, ie:

a) Roads & Transportation Division of the Public Works Department,
b) Mass Rapid Transit Corporation,
c) Registry of Vehicles, and
d) Land Transport Division of the Ministry of Communications

LTA's mission is:

'to provide a quality, integrated and efficient land transport system which meets the needs and expectations of Singaporeans, supports economic and environmental goals, and provides value of money'

Under the new Rapid Transit Systems Act, LTA is responsible to plan, design, build, operate and maintain rapid transit systems in Singapore, as well as to regulate the operation of these systems which cover both Mass Rapid Transit (MRT) and Light Rail Transit (LRT) or other people-mover systems.

LTA has spelt out in a White Paper published in early 1996, its strategies to provide a world class public transport system for Singaporeans of which the corner stone is a comprehensive rail network comprising MRT and LRTs. It is envisaged that there will be at least 160 kms of MRT and LRT in Singapore over the long term inclusive of the existing 83-km MRT and the new 8-km LRT and 20-km MRT lines currently being constructed.

Rail Industry of Singapore

In Singapore, there are four key players in the rail industry:

- LTA plays the role of infrastructure developer and is responsible for the planning, design and construction of rail systems. Completed systems will be handed over to private operators to operate and maintain.

- LTA also plays the role of rail regulator and infrastructure controller and is responsible for granting licences to private rail operators and for ensuring that the licensees provide and maintain an adequate, safe and satisfactory service. It is also responsible for controlling the activities taking place on or associated with the rail infrastructure.

- Private operators play the role of service providers and are responsible for the operation and maintenance of rail systems. Currently, Singapore MRT Pte Ltd is the private operator of the existing 83-km MRT system.

- The Public Transport Council plays the role of industry watchdog and is responsible for approving the fares of rail services and for monitoring the service performance.

Safety of people using and engaged in work on the rail systems is regulated by two principle legislations, namely:

Rapid Transit Systems Act	It empowers LTA to, among other things, impose conditions on safety of persons using or engaged in work on a rapid transit system in granting a licence to an operator.
Factories Act and associated Regulations	These are administered by the Ministry of Labour and regulate the health and safety at work and in particular, the health and safety of railway employees.

Life-Cycle Approach

LTA is in a rather unique situation where it has dual roles in connection with rail projects, one of development and the other of regulation and control. These roles required LTA to assure the safety of its own activities as well as those of service providers during the entire life-cycle of rail projects. In view of this, LTA is developing an integrated SMS known as Project Safety Review (PSR) for systematic assurance of safety at various stages of rail projects throughout the projects' life-cycle, from inception through implementation till disposal. This paper provides the background of the SMS development and outlines the proposed framework of safety regulation, safety validation and other management processes for safety assurance.

DEVELOPMENT OF PROJECT SAFETY REVIEW

Purpose of PSR

In a rail project, safety-critical activities are undertaken at various stages during the project's life cycle. The key stages are:

- concept development/planning
- design/engineering
- construction
- testing & commissioning
- operation and maintenance

The purpose of developing the PSR is to have a single integrated SMS that cover all the activities during the various stages of rail projects, carried out by both the developer and service provider, and provide a robust framework to assure that safety is rigorously considered and that risks are identified, eliminated, controlled or mitigated in the system development/operation process.

Implementation of PSR will enable formal control mechanisms and management processes to be established to:

- systematically identify, evaluate, control and manage all safety risks associated with a rail project

- ensure the parties undertaking safety-critical activities have the commitments and resources to manage safety effectively

- clearly assign the responsibilities for safety

- self regulate LTA's own activities that affect safety

- explicitly and formally document the safety issues addressed and decisions made during the development process

- facilitate audits on compliance and monitoring of safety performance

- provide comprehensive documentation confirming the safety during the development process for reference by the operators and contractors

- objectively evaluate the cost and benefit of safety measures

- drive the process of continues improvement in safety

Benefits of PSR

The benefits of implementing the PSR include:

- avoid late-stage changes and abortive works
- avoid imposition of constraints on system operation through elimination of hazards during the system development process
- enable optimum selection of design and operating options
- ensure high reliability and availability of systems
- facilitate the development of operational, maintenance and emergency procedures
- ensure consistent understanding of safety requirements among all parties involved in a project
- promote positive safety culture and safety awareness
- enhance public confidence on and acceptance of the systems

Elements of PSR

A multi-discipline project team was formed in May 98 to spread head the development of PSR. A PSR Manual is expected to be produced by end 98 which will serve as a reference document for future implementation of PSR.

PSR is intended to be goal-based and hence it will not be over prescriptive. It addresses three key aspects of safety management, ie commitments and resources, management controls, safety standards and criteria. Various elements of PSR to be developed are shown in Fig. 1.

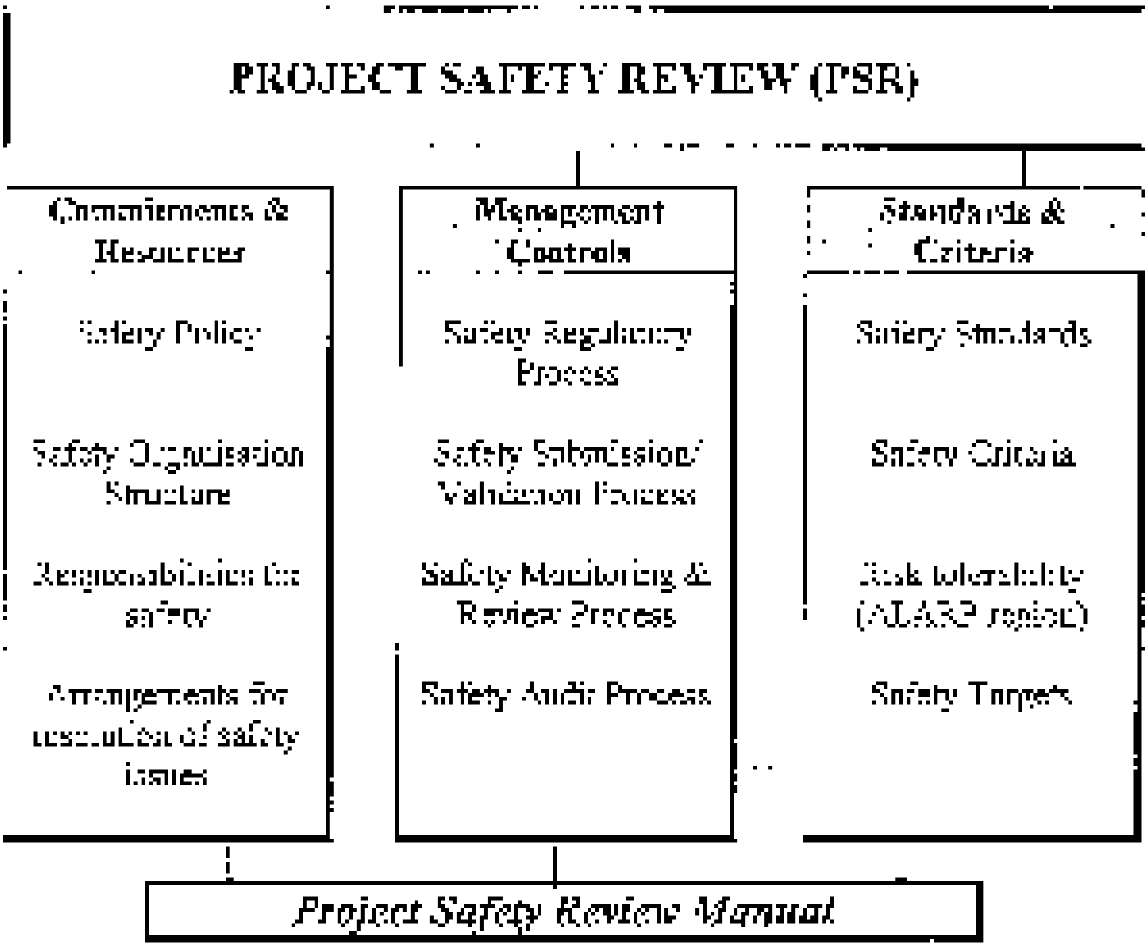

Fig. 1 Elements of Project Safety Review

FRAMEWORK OF PROJECT SAFETY REVIEW

PSR is based on structured management control processes and clearly defined responsibilities and roles of the parties involved in rail projects, ie:

- Developer (LTA)
- Service Provider (Private Organisation)
- Safety Regulator (LTA)

The concept is illustrated in Fig. 2

The role of the Safety Regulator is to develop the safety policy, set safety standards, risk tolerability criteria, performance targets etc. Its primary responsibility is to assure safety. To avoid the possibility of conflict of interest the Safety Regulator will be an independent department within LTA that will not have responsibilities for planning, designing and constructing rail systems.

Developer or Service Provider has primary responsibility for achieving safety. They are to provide a demonstration to the Safety Regulator that an adequate level of safety will be or is being achieved. Two key aspects to be demonstrated are:

- Hazards/Risk - These must be identified and understood. The risk of harm to persons must be at a tolerable level and must be as low as reasonably practicable.

- Business processes - These must explicitly provide for the management of safety by means of an adequate SMS.

Safety Regulator is to review the safety demonstration by the Developer or Service Provider and to either accept or reject the demonstration. Safety Regulator may also carry out compliance audits and conduct accident/incident investigations.

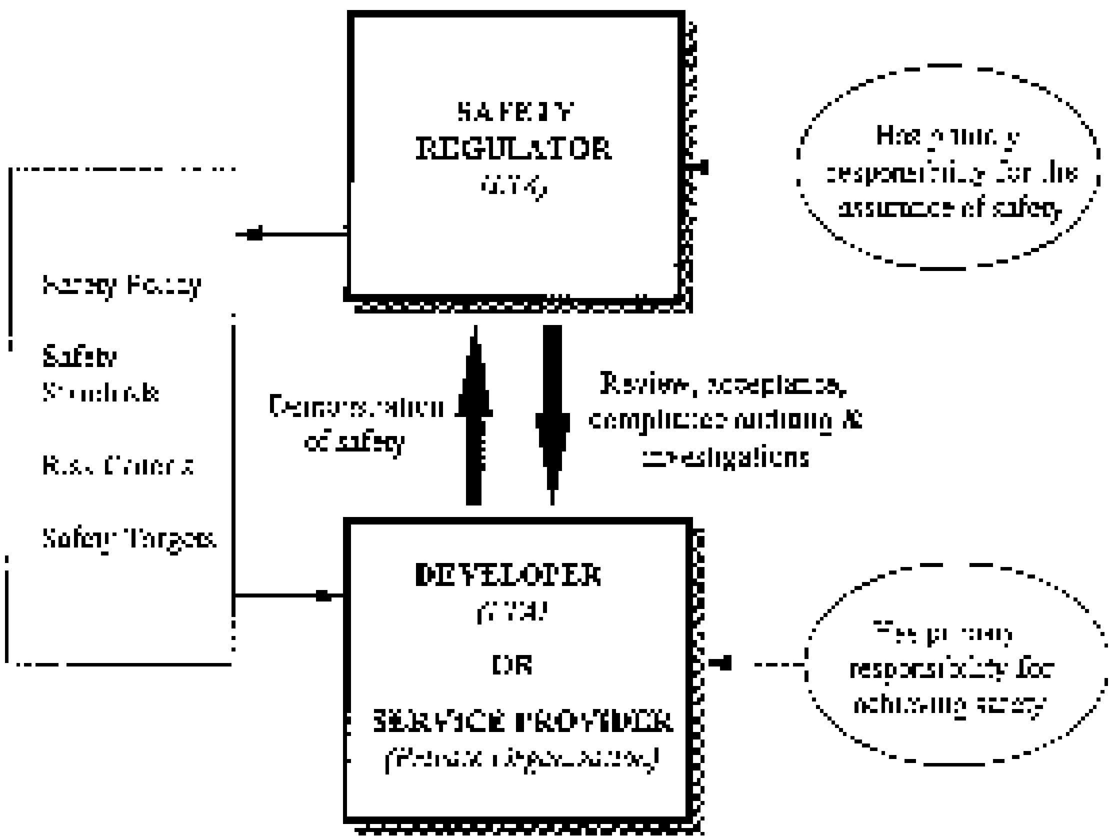

Fig. 2 Concept of Project Safety Review

Safety demonstration will be in the form of formal safety submissions. Such submissions are required at key stages of a project as shown in Fig. 3.

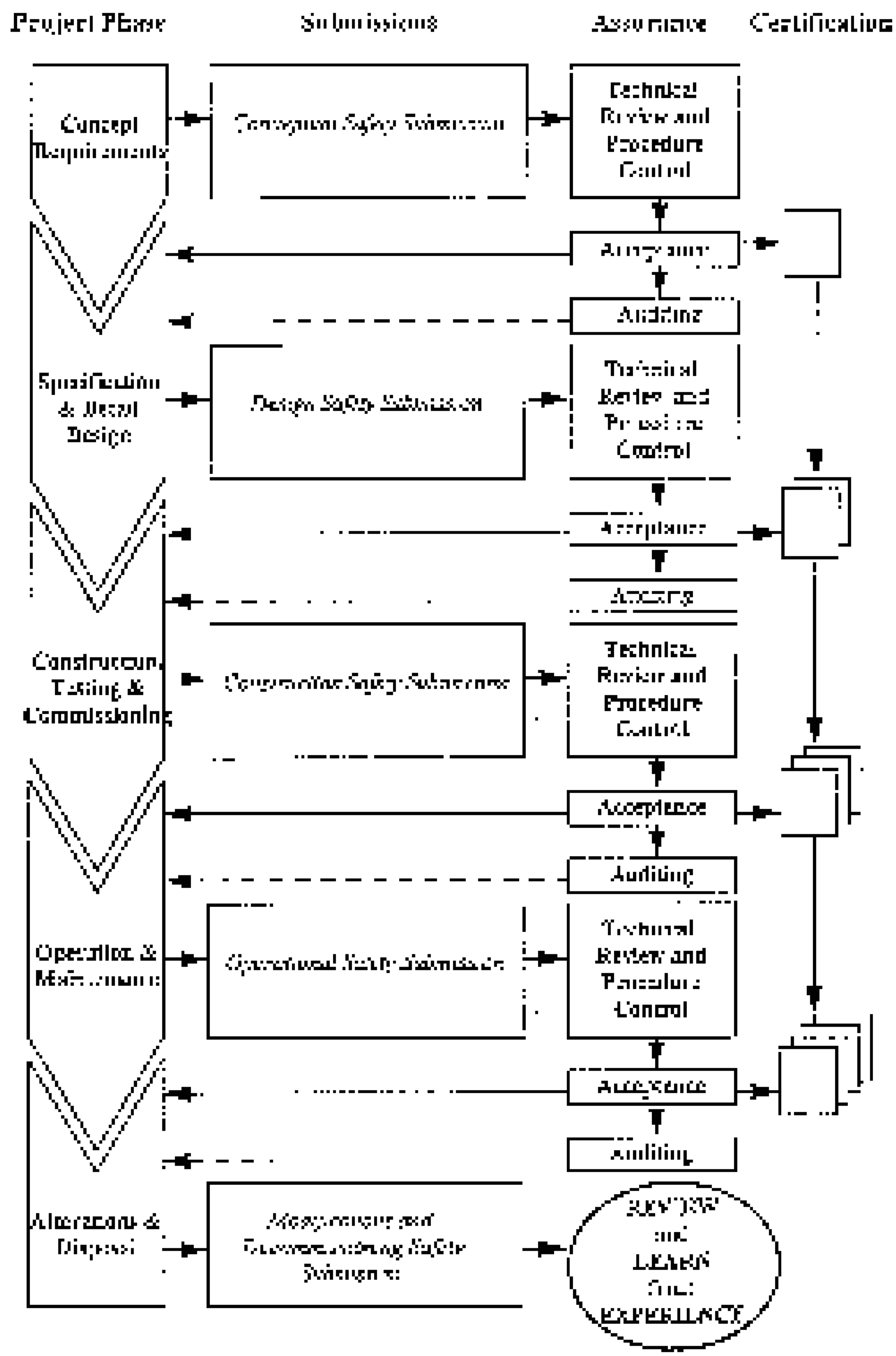

Fig. 3 Framework of Project Safety Review covering the key stages during a project's Life-cycle

The safety submissions will need to address or justify the following issues.

- safety management system
- safety principles
- safety standards
- safety criteria

As shown in Fig. 3, acceptance of safety submissions is a necessary condition for a project to proceed or an operation to commence.

The entire PSR process will be integrated into the existing engineering and management processes to avoid unnecessary bureaucracy and paper works.

CONCLUSION

The Land Transport Authority is responsible for both the development and regulation/control of rail systems in Singapore. It is currently developing an integrated SMS known as Project Safety Review, to systematically and rigorously assure the safety of rail projects throughout the projects' life-cycle, from inception through implementation till disposal. It covers the activities of LTA on its own as well as those of service providers. The ultimate objective is to have a robust SMS to enable a high level of safety performance is achieved in the development and operation of rail systems, in support of LTA's vision for a world class transport system. The PSR is still being developed and more details will be available at a later stage.

ACKNOWLEDGMENT

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Paper 9616

Percy T. F. Kong

Systems Assurance: Design and Implementation

CURRICULUM VITAE

Kong Yat Fun Percy

Since graduation from the University of Hong Kong in 1988, Mr Kong was recruited by the Corporation as a Graduate Engineer under accredited training scheme. He has been the Support Engineer in the Project Department and took part in the design and commissioning of railway extension projects for 2 years.

Then he joined the Operations Engineering Department as a Design Support Engineer for 4 years, responsible for the design and operational support of HV & LV Power Supply Systems. Up to the present, Mr. Kong is working on the verification and validation of integrated system performance (hardware, software, liveware) within MTR operating context and application of Systems Engineering methodology on major asset renewal process.

Systems Assurance - Design & Implementation

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SYNOPSIS This paper describes the functional operation of the Systems Assurance process with particular emphasis on the System Operational Analysis leading to the design of Integrated System Test and Contingency System Test. Business success is not coincidental. System testing is a risk reduction process that requires the same investment process as system design. System testing can only be effective designed at the acquisition phase. Case study examples concerning the tunnel ventilation system are discussed regarding the integrated system performance of systems in operation (hardware, software, liveware and management). Emergency system tests shall be the basis of any improvement initiatives. Business / professional ethics and social responsibilities are the emergent issue.

1. INTRODUCTION

1.1 Operating Railway

The Mass Transit Railway was built through one of the most densely populated areas in the world with minimum disruption to the local environment. MTR runs through the most densely populated residential and commercial areas of Hong Kong Island and Kowloon.

The overall route length of the system is 43.2 km and consists of three lines. Each was built at different times and the first passenger service came into operation in late 1979. There are now a total of 38 stations, 29 of which are underground. MTR trains consist of eight linked carriages with open access all the way through.

The trains have a top speed of 80 km/hr and an average running speed of 33 km/hr. The average waiting time for trains is less than 2 minutes during peak hours and run 19 hours 7 days a week. At present, the MTR carries over 2 million passengers every weekday and over 80,000 passengers / dir / hour making it one of the busiest in the world.

1.2 Safety Management Development

Emanating from a review on Safety Management Progress in the Operations Engineering Department in 1991, a need to more fully analyse the systems and system interfaces was identified. To ensure that the railway engineering systems, including human operators, will respond as required, particularly under degraded or emergency conditions, it is recommended that a measure of upgrading in engineering support be established - *the evolution of Systems Assurance.*

2. SYSTEMS APPROACH

2.1 Concept of a System

A system is defined as :

" A set of components inter-connected together in an organised way in such a way as to accomplish a specific function at a set level of performance. "

The systems approach begins with the identification / definition of needs. Accordingly, the mission and objectives of Systems Assurance are tailored to meet the business objectives.

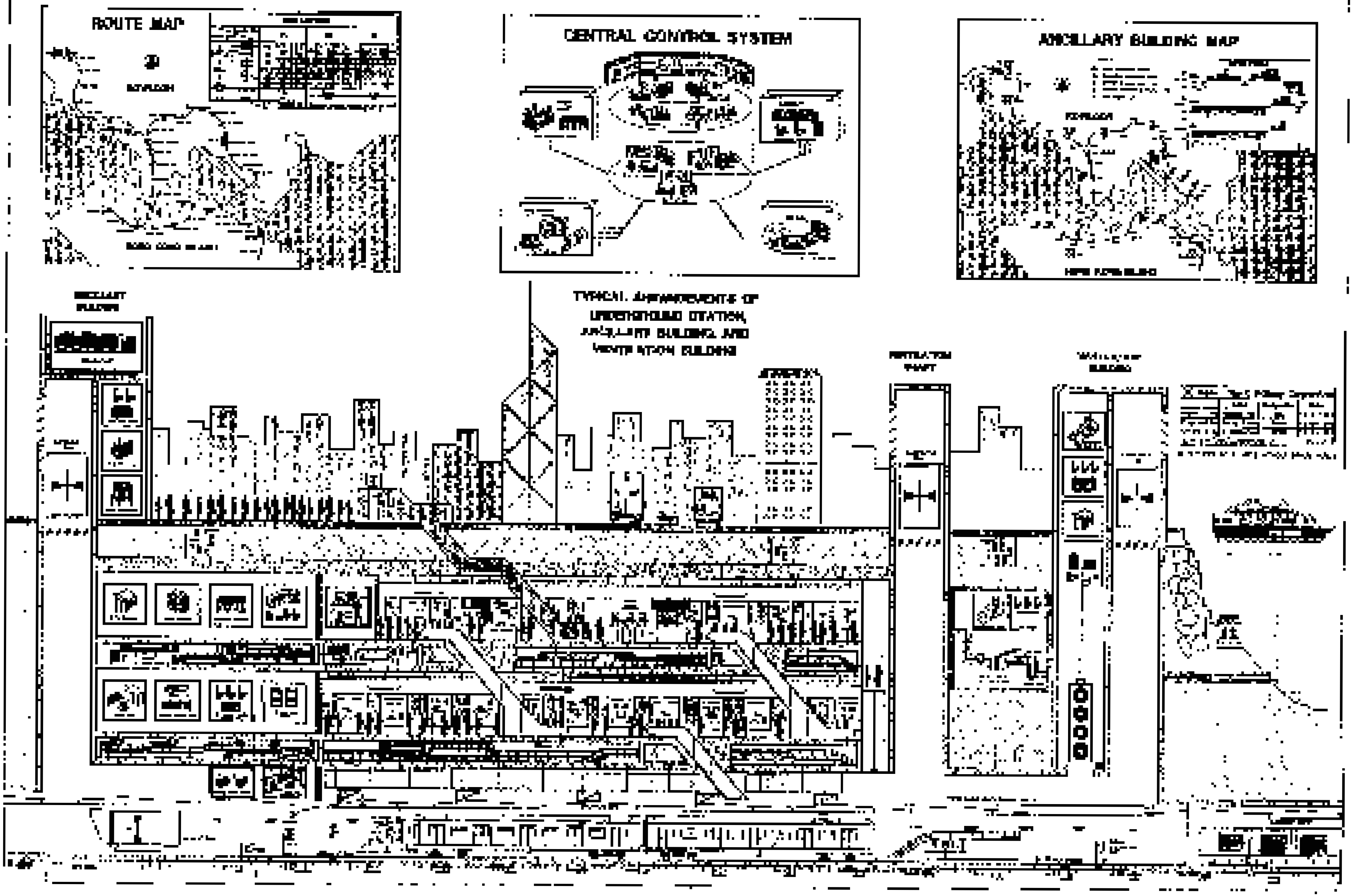
2.2 Systems Engineering

<u>The Process</u>

Systems engineering is a process that has only recently been recognised to be essential in the orderly evolution of man-made systems. It involves the application of efforts to :

- Transform an operational need into a description of system performance parameters and a preferred system configuration through the use of an iterative process of functional analysis,

AN OVERVIEW OF MASS TRANSIT RAILWAY SYSTEMS AND ITS OPERATING CONTEXT



synthesis, optimization, definition, design, test, and evaluation ;

- Incorporate related technical parameters and assure compatibility of all physical, functional, and program interfaces in a manner that optimizes the total system definition and design ; and

- Integrate performance, producibility, reliability, maintainability, manageability, supportability, and other specialties into the overall engineering effort.

In short, the Systems Engineering is a process to secure a balance of efficiency and effectiveness (value for money) in practical terms under the TQM environment.

2.3 Potential Benefits

The potential benefits of adopting systems approach are :

- To minimise inherent defects ;
- To minimise engineering effort and schedule ;
- To minimise design, operations, maintenance and support costs ;
- To maximise utilisation of available assets including people ;
- To maximise system users' satisfaction.

3. SYSTEMS ASSURANCE

3.1 Management Philosophy

Systems Management Re-engineering

The significance of Systems Engineering process is not recognized in the past railway projects. Business success is not mandatory, systematic failures are likely to have been built-in before the system became operational.

The methodology of Systems Management Re-engineering is adopted :

" The examination, study, capture, and modification of the internal mechanisms or functionality of existing system management processes and practices in an organisation in order to reconstitute them in a new form and with new features, often to take advantage of newly emerged organisational competitiveness requirements, and often through use of new and emerging technologies. "

Based on the mentioned concept, an attempt has been made to design a process for re-engineering the MTR system.

Mission

The mission statement is :

" To ensure that the railway engineering systems available to the system users are in a continuous ready state so as to enable precaution, prevention and protection of high-level hazards in a proactive and cost-effective manner ".

Dependability is the focus of analysis. High-level hazards refer to failures having significant impact on business and system users in terms of safety and service provision.

Objectives

The prime objectives of Systems Assurance are :

- To detect system hidden failures ;
- To identify system weaknesses ;
- To verify and validate system performance ;
- To predict system performance ;
- To define effective maintenance policy.

Strategy

The operating strategy of Systems Assurance is :

" To integrate the functions of hardware, software, liveware and management in the operating context "

Differentiation by hardware for efficiency and integration by function for effectiveness.

Goal

The goal of Systems Assurance is :

" To ensure that systems and people remain effective for purposes during the whole life and renewal cycles ".

3.2 Process

The Systems Assurance consists of eight steps :

Step 1 System Operational Analysis

This first step is to analyse and re-thinking the mission & functions of systems in operation fundamentally, by constructing the System Diagrams, System Operational Flow Diagrams etc.

[illegible] and to analyse the system functional interfaces in terms of [illegible], control, monitoring, and protection.

Step 2 System Hazard Analysis

This step involves looking for critical systems that failures will have significant impact on business, system users and determining the improvement opportunities by making informed judgement on whether it will be beneficial to invest resources on analysing the system functions, predicting potential hazards ([illegible]) and failure modes, estimating potential loss saving, and the feasibility of verifying & validating the hazards.

Step 3 System Test Specification

This step defines the general strategy of identifying potential problem areas, testing methodology adopted, setting priority of function testing, test case dimensions, test areas and testable items.

Step 4 Man Machine Interface Analysis

For the system under test, a preliminary appraisal on the five usability attributes of learnability, efficiency, memorability, errors and satisfaction is assessed.

Testable and functional attributes considered critical may be incorporated in the system test design.

Step 5 Test Case Design & Development

This step covers the Work Breakdown Structure of system under test, the scope and level of test, priority of test case.

Step 6 System Test Implementation

This step determines the specific test areas & testable items, [illegible] standard / requirements, particular test objectives and targets.

During this step, the system test plan, testing method statement, procedures and record forms are [illegible] for carrying out field tests.

Step 7 System Assurance Report

After analysing the test results, consolidating the findings, the recommendations for improvement and remedy ([illegible] & procedure) will be made for management's consideration.

Step 8 Monitoring & Review

This step involves the periodic review of the following actions to ensure project completion.

The life cycle of Systems Assurance is depicted in Figure 3.

3.3 Supporting Tools & Techniques

The following technical & management tools have been adopted to support the Systems Assurance :

- Operations Management ;
- Systems Engineering & Management ;
- Reliability-Centred Maintenance ;
- Usability Engineering ;
- System Safety Engineering ;
- Management of Emergency Preparedness
- Formal methods of System Testing & Management

4. PROGRESS & ACHIEVEMENTS

Apart from designing a workable mechanism [illegible] to fulfil the designated job requirements, the most important issue is to realise the plans.

In the past three years, about 50 recommendations ([illegible], procedural etc) have been made and about [illegible] high level [illegible] have been identified, verified and validated. It is estimated that at least HK$[illegible] million / year loss saving is estimated ([illegible]). Thus, the mission is commercially viable for existing assets.

It is observed that the major problem areas are the integrated performance of " Operating & Design " and " Design & Maintenance " functions.

5. CASE STUDY EXAMPLES

The following systematic failures concerning tunnel ventilation system under emergency operations are quoted for demonstration purpose. The overview of MTR tunnel ventilation is shown on Figure 4 :

Case 1 Air Flow " Short Circuit "

The extracted smoke from the tunnel in emergency is drawn into the rescue tunnel when the combined operations of emergency fans, emergency procedures and ventilation building dampers are analysed (see Figure 5).

Case II — *Air Path " Bypass "*

The smoke-laden air coming from [illegible] tunnel end is bypassed by the crossovers / turnouts when the combined operations of emergency fan modes, train to tunnel emergency procedures, tunnel layout are analysed (see Figure 5).

Case III — *Insufficient Ventilation*

The chance of effecting smoke extraction operations at certain tunnel sections is about 0.4 when the combined operations of emergency fans, emergency procedures, physical tunnel layout, control panel layout design and system performance are analysed.

Case IV — *Unintentional Shut Down*

The emergency fans at a number of stations in areas will be tripped and locked out when the combined operations of tunnel ventilation fans, electrical [illegible] mechanical plants, protective device and emergency procedures are analysed.

6. THE WAY FORWARD

The process of Systems Assurance will turn into two directions :

First Phase

To re-engineering [illegible] tunnel ventilation system of the existing railway system, identifying, verifying and validating weaknesses and deficiencies (combination of software, hardware and human and operating errors).

Second Phase

The practical application of System Engineering process such as the implementation of " System Specification " for major projects

Long-Term Goal

The establishment of System Engineering Management System that integrates the [illegible] complex management & functional elements and business into a single entity (see Figure 6).

7. DISCUSSION

Business-Centred Management

Functional maintenance refers to all activities intended to keep technical systems in or restore them to the state being considered necessary to fulfil their intended mission.

Business-centred management is defined as the efficient application of resources to control and reconcile actual system behaviour to the effective attainment of business requirements.

There is little point in spending billions of dollars on acquiring, operating and maintaining an ill-defined system.

Business Ethics and Social Responsibilities

It may be high time for the management to rethink the long-term operations strategy. Apart from establishing engineering management and documentation systems, professional understanding and mastering of systems in operations (Software) are of fundamental importance.

8. CONCLUSION

The system analysis and incremental system tests have demonstrated the presence of built-in systematic failure in MTR.

The adoption of Systems Assurance process for re-engineering the system and the Systems Engineering Management System will minimise the extent of inherent defects, engineering errors and schedule that meet the implicit need of fare paying system users (who form the ultimate users).

System users shall be the focus of any improvement initiatives taking into considerations of business requirements and social responsibilities.

REFERENCE

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2. *Systems Engineering Management, by B. S. Blanchard*
3. *Systems Management, by Andrew P. Sage*
4. *Reliability-Centred Maintenance, by J. Moubray*
5. *System Safety Engineering and Management, by Roland Moriarty*
6. *Railway Engineering, by [illegible]*

EMERGENCY FAN MODE OPERATION

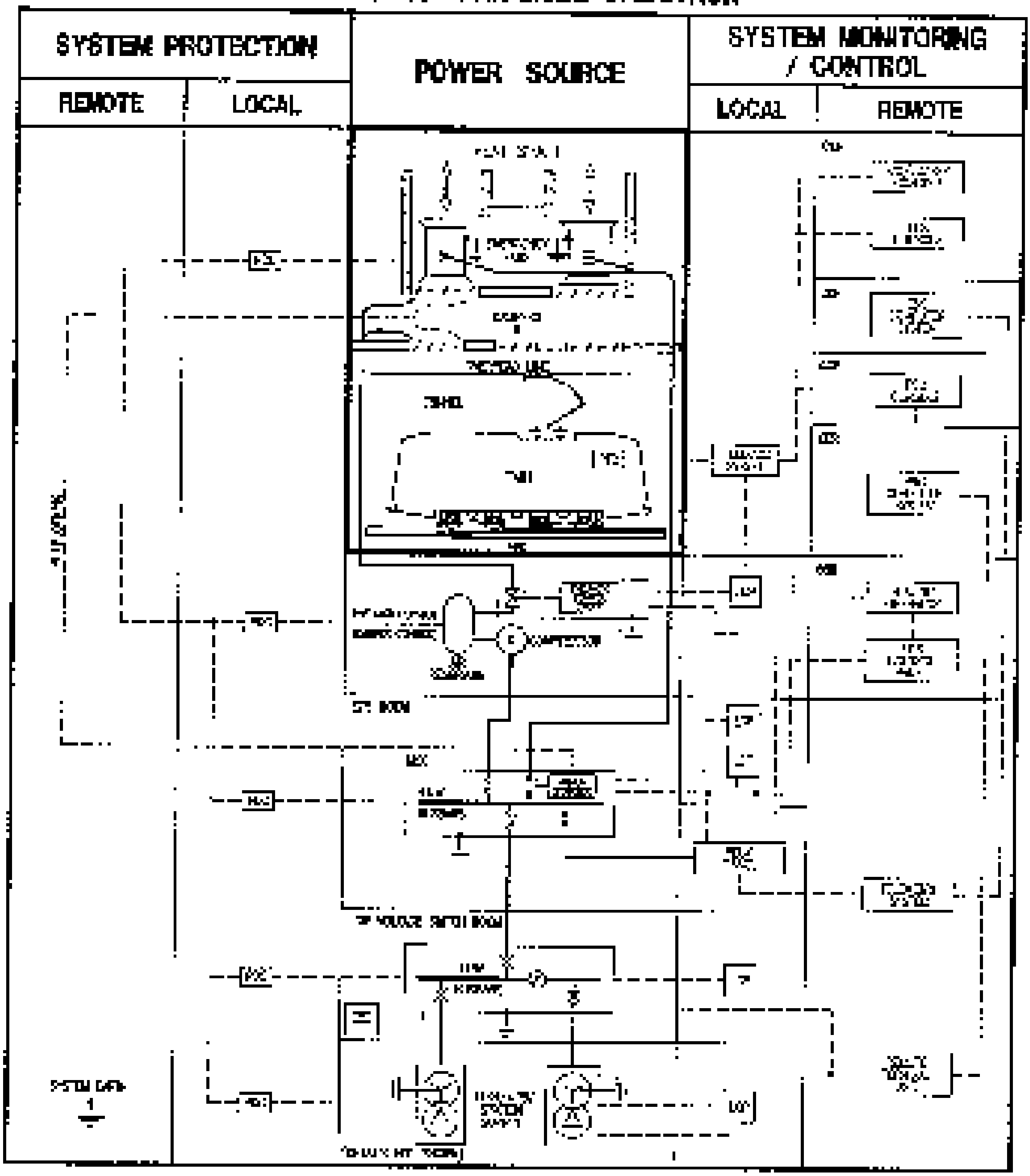


FIG. 1

MASS TRANSIT RAILWAY CORPORATION

SYSTEM DIAGRAM –
EMERGENCY FAN MODE OPERATION

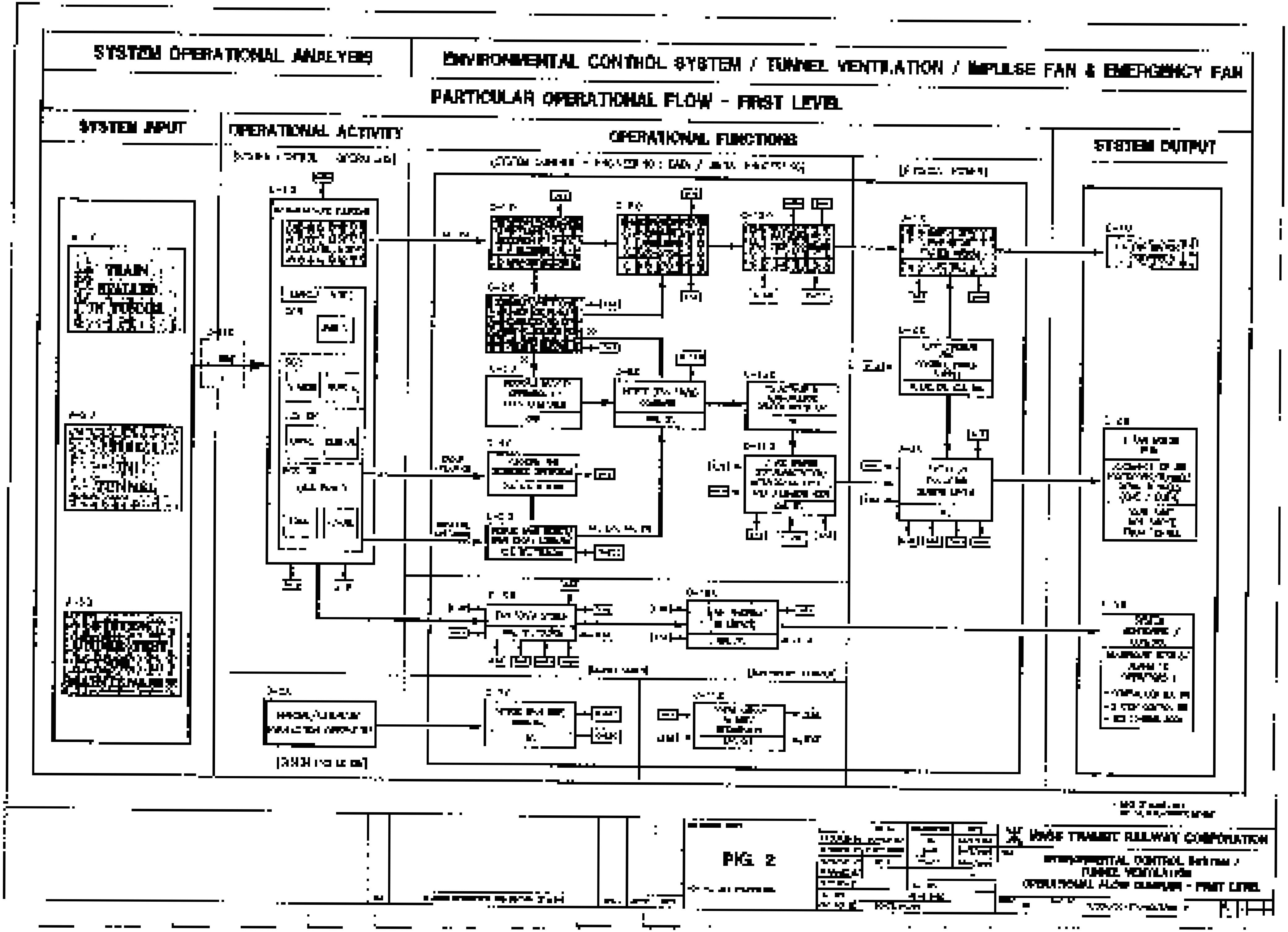

SYSTEM OPERATIONAL ANALYSIS
ENVIRONMENTAL CONTROL SYSTEM / TUNNEL VENTILATION / IMPULSE FAN & EMERGENCY FAN
PARTICULAR OPERATIONAL FLOW - FIRST LEVEL
SYSTEM INPUT
OPERATIONAL ACTIVITY
OPERATIONAL FUNCTIONS
SYSTEM OUTPUT
TRAIN
MASS TRANSIT RAILWAY CORPORATION
ENVIRONMENTAL CONTROL SYSTEM / TUNNEL VENTILATION
OPERATIONAL FLOW DIAGRAM - FIRST LEVEL

FIG. 2

FIG. 3 LIFE - CYCLE OF SYSTEMS ASSURANCE

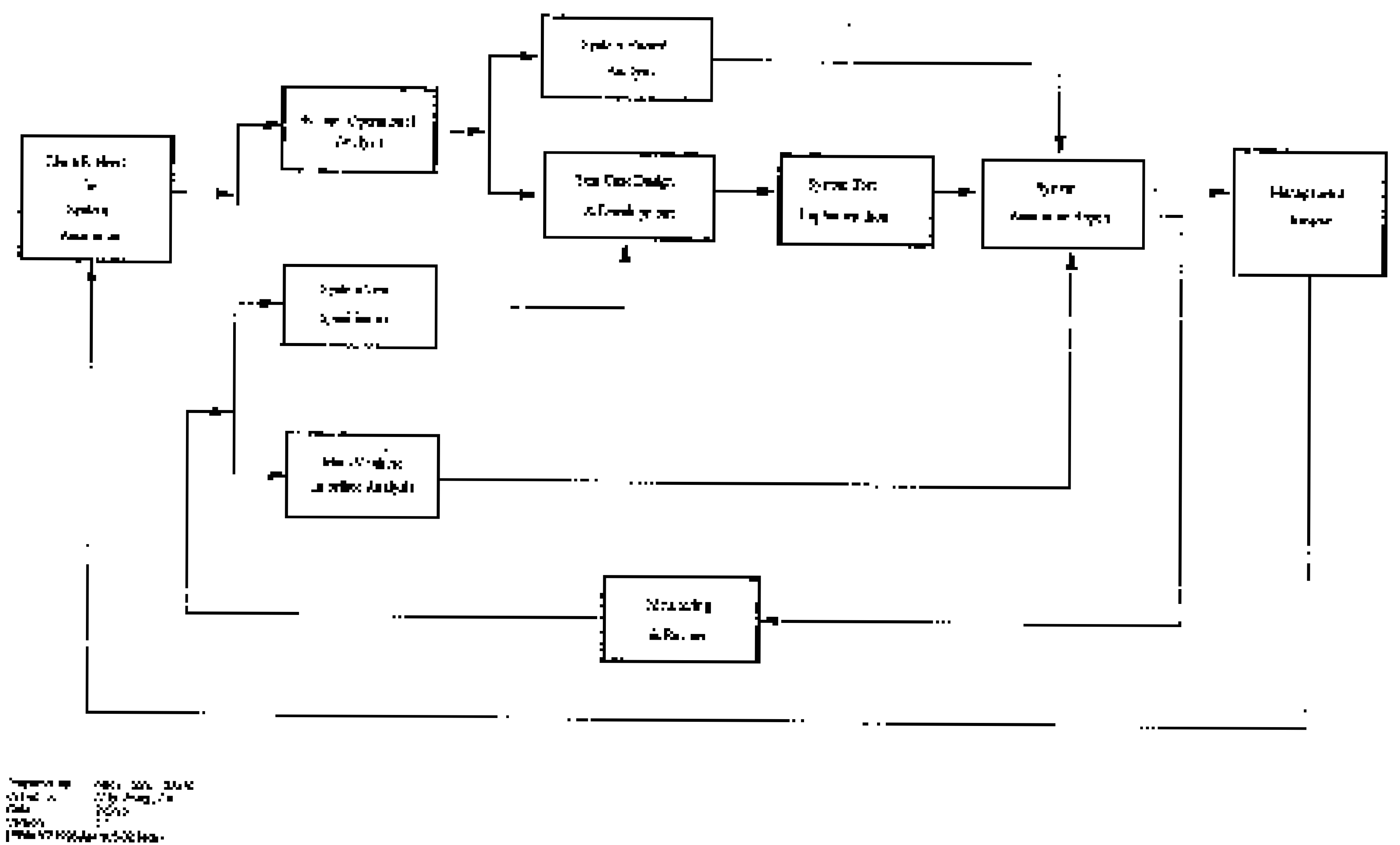
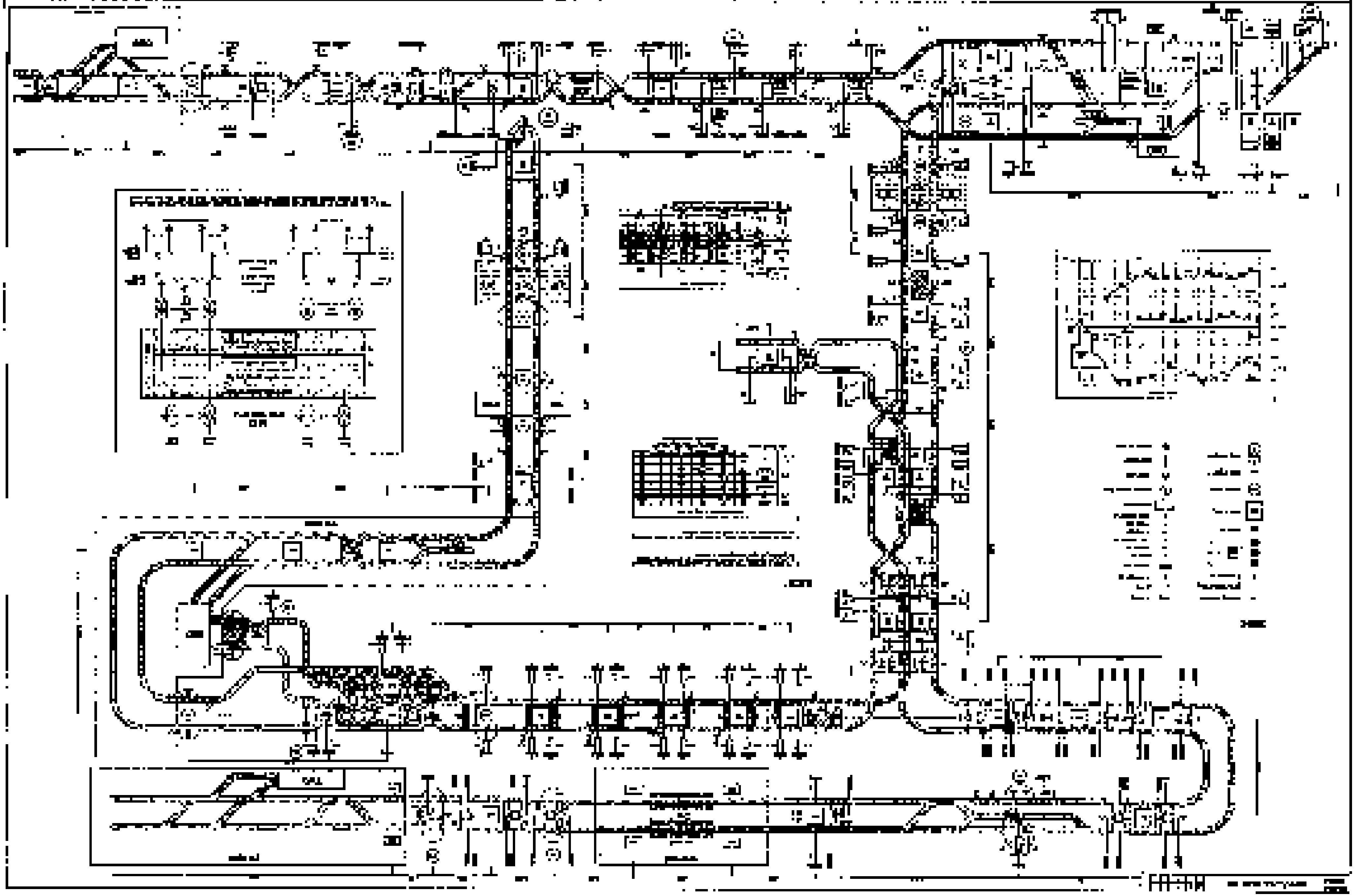


FIG. 4



SYSTEMATIC FAILURE – TYPICAL EXAMPLE

TUNNEL VENTILATION SYSTEM

EMERGENCY PROCEDURES + EMERGENCY FANS + BUILDING STRUCTURE + EMU + SYSTEM OPERATORS = SYSTEMATIC FAILURE

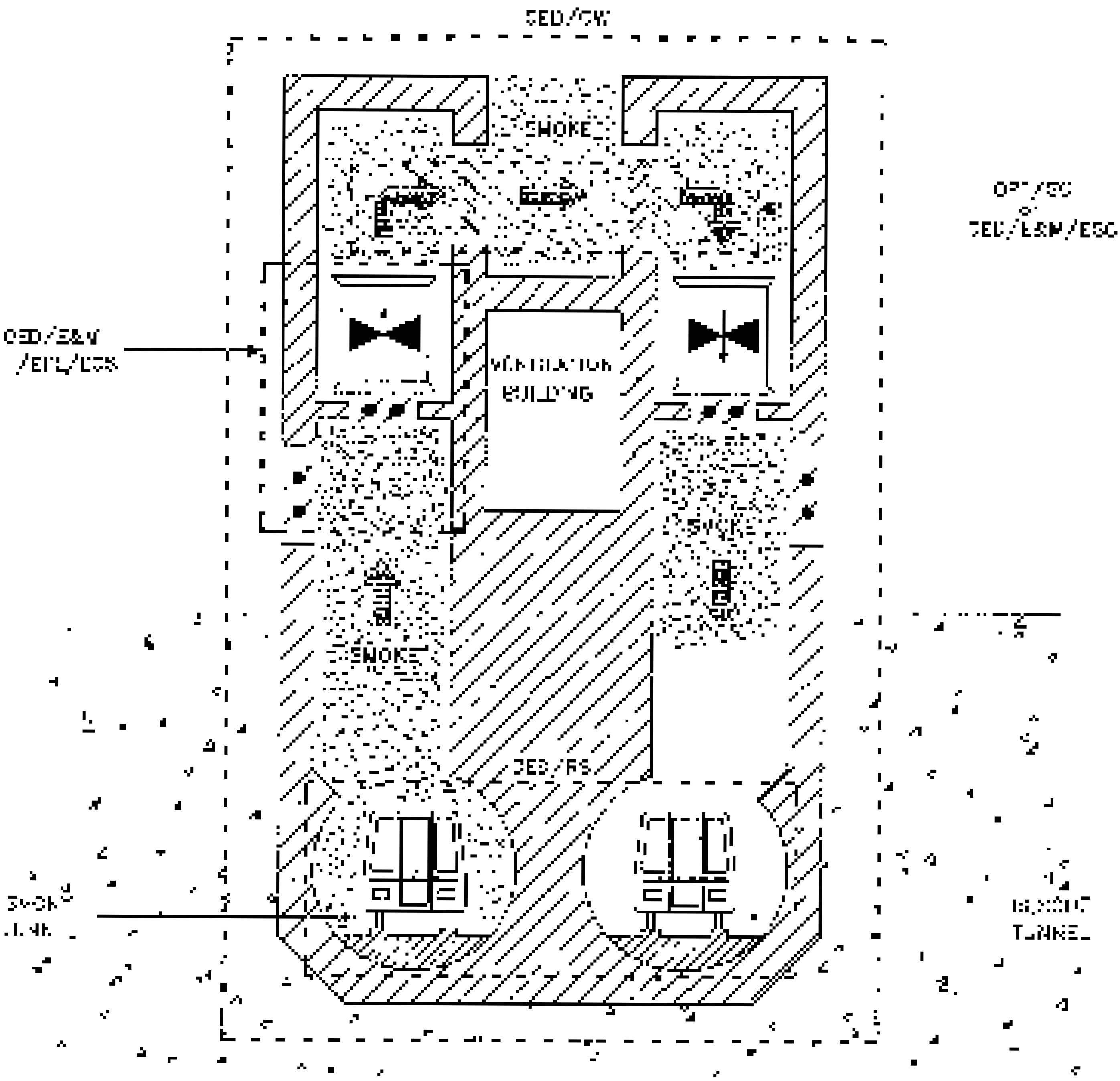


Fig. 5

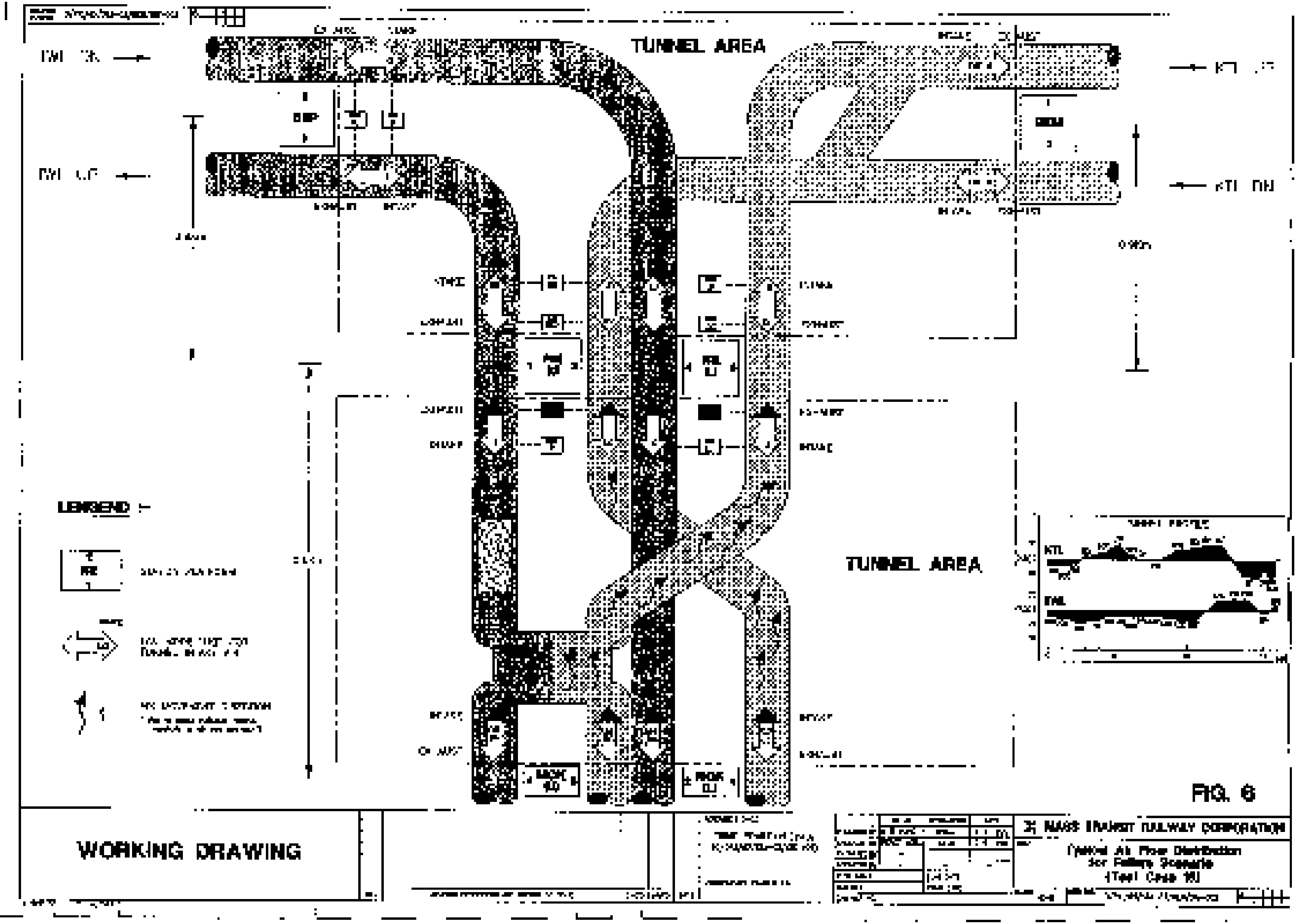

TUNNEL AREA
TUNNEL AREA
LEGEND :-
WORKING DRAWING
MASS TRANSIT RAILWAY CORPORATION
Typical Air Flow Distribution for Failure Scenario
(Test Case 10)

FIG. 6

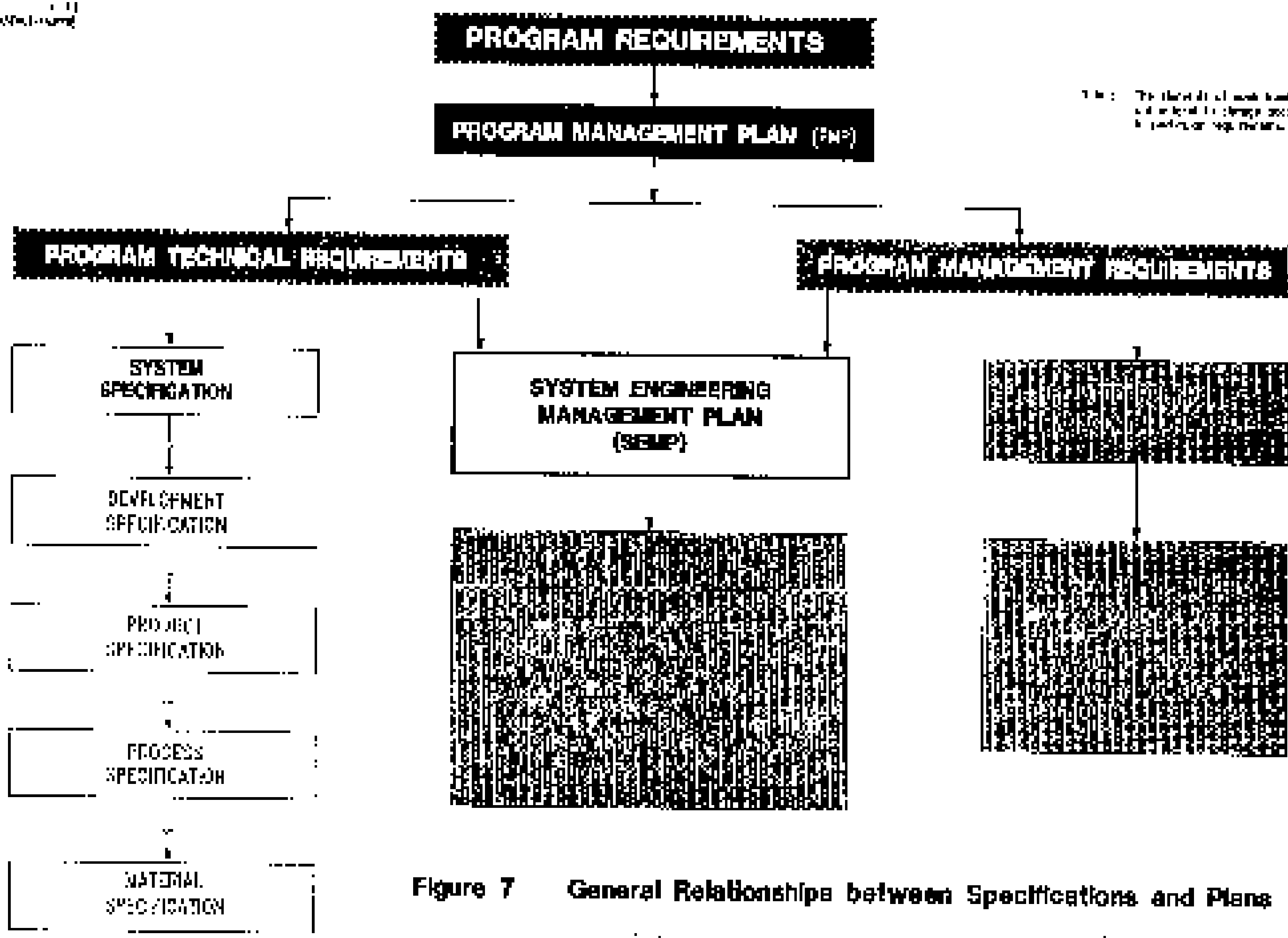


Figure 7 General Relationships between Specifications and Plans

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N, Kris Mnisi

Safety Awareness in Swaziland

Publisher
IRSC International Rail Safety Conference

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Swaziland Government. Department of Labour - Labour Inspector (Industrial relations)

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Swaziland Railway - Diesel Electric Locomotive Operation

1993 - present
Various safety management training by NOSA including SAMTRAC.

Safety Awareness at Swaziland Railway

by

N.K. Muisi
Safety Manager
Swaziland Railway Headquarters

SAFETY AWARENESS AT SWAZILAND RAILWAY

The Background

Swaziland Railway was established by the Swaziland Railway Act of 1962. The Act cites the duty of Swaziland Railway as the provision of an efficient and adequate system of transport of goods and passengers by rail with due regard to economy and safety of operations and to supply needs of Swaziland rail services to the fullest possible extent consistent with the resources of the Railway.

Swaziland Railway is responsible for the infrastructure, rolling stock and operation of a 300 kilometre railway system stretching from Matsapha to Siweni (for Maputo) and from Lavumisa to Komatipoort. On the 60 kilometres from Mananga to Komatipoort (Republic of South Africa) Swaziland Railway is not responsible for the infrastructure.

Swaziland's rail network begins at Matsapha Industrial Site, where several private sidings are established. From Matsapha the line runs East to Phuzumoya where it links with Lavumisa in the South to connect with the South African ports of Richards Bay and Durban. The North/South line provides a direct route via Swaziland for traffic to and from the Natal coast ports to link with such countries as Zimbabwe, Zambia, Malawi and Zaire (see Annexure A). The Corporation provides for about 700 jobs providing townships with relevant services like recreation clubs, schools and medical services.

Safety Programme (Annexure B - Safety Policy Statement)

As a result of a bad experience of accidents previously in 1993 the Railway Administration and the Labour Union reached a consensus to embark on a Safety Programme as a permanent feature of Swaziland Railway operations. The Programme purported to run on committee basis where different levels and categories of employees are represented in Safety Committees which meet monthly to discuss safety issues and conduct inspections.

Under this programme campaigns were launched to promote Safe Working like the "Anti-derailment/Accident campaign" where busy shunting yards competed to have an accident free three month consecutive period to achieve a celebrative meal (barbecue) and the monthly Individual Safety Gradings which after a year give each of the graded categories an annual "Safety Charter". The campaigns had various degrees of success.

2/..

[The anti derailment campaigns have since been suspended as most employees never really exerted themselves to earn these braais.

The Individual Safety Gradings have been introduced for Train Crews, Signals and Telecommunications personnel and some shunters based at Mpaka Station (with the rest of the shunters resisting the gradings)

<u>The Gradings</u>

The Individual safety gradings are aimed at promoting a culture of safe working within the organisation. The employees concerned draw up grading parameters relating to safe and efficient working with the assistance of the Safety Unit. The employees make their own parameters as they are the specialists in their jobs and are best placed to know what constitutes safe working in their field. Monthly the employees are graded by their Safety Committee using information obtainable from daily occurrence registers. Every employee is encouraged to report any unsafe act or condition to the safety representatives for correction and to facilitate gradings.

Mistrust has greatly affected the successfulness of the safety grading as some employees resist them for fear of victimisation. This fear is basically fear of the unknown rather than fear of clearly emminent danger.

<u>Conscientisation</u>

The monthly Safety Committee meetings also aim to conscientise people on the role they are to play to encourage safe working and its benefits. On weekly basis the Safety Representatives are to have one 15 minutes safety briefings with the people they represent on one safety related subject per week.

This is what is supposed to happen but the Safety Unit has been having to deal with a lot of negative attitudes as workers and supervisors see it as a time waster as they have been working without such since the inception of the corporation. To try to promote awareness the Safety Unit contributes safety news to a quarterly railway magazine in a somewhat entertaining manner for light reading. (Annexure C).

Case Studies (Annexure D)

Case studies are done on significant incidents to enable review and the taking of corrective action. The case studies are also presented to the monthly meetings to pursue the conscientisation drive.

Observations

There has been some improvements in the occurrence of accidents since the launching of the Safety Programme. For example prior to 1993 in five (5) years at Swaziland Railway we had statistics of an average of one member of the train crews dying annually. Since 1993 we have not had such fatality in four (4) years.

We are not happy with the attitudes employees display toward the subject of safety so we took a decision to involve NOSA (National Occupational Safety Association - A South African Safety Watchdog Organisation) in the education of our workforce. We expect the NOSA involving drive to last for ten (10) years after which we hope 100% of all our employees will be adequately safety conscious.

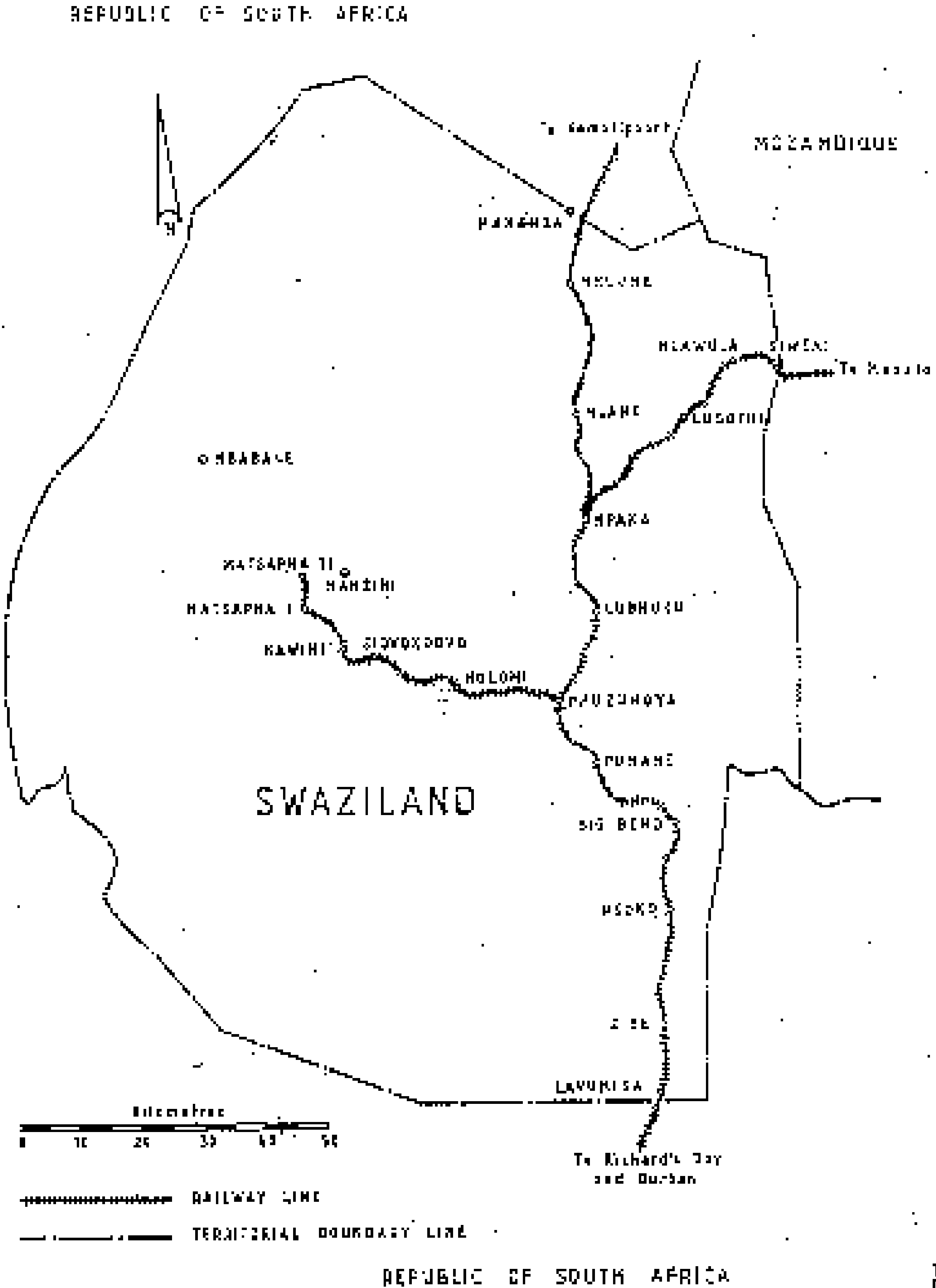
The aim of Swaziland Railway in attending this conference is to learn from the vast experiences of the presenters and also relate the little experience we have so as to solicit advice.

N.K. Mnisi
SAFETY MANAGER
SWAZILAND RAILWAY HEADQUARTERS
JOHNSTONE STREET
P.O. BOX 475
MBABANE
SWAZILAND
SOUTHERN AFRICA

Tel. (09268) 42486/7/8
Fax: (09268) 45009
HRE/006/06 (KB)

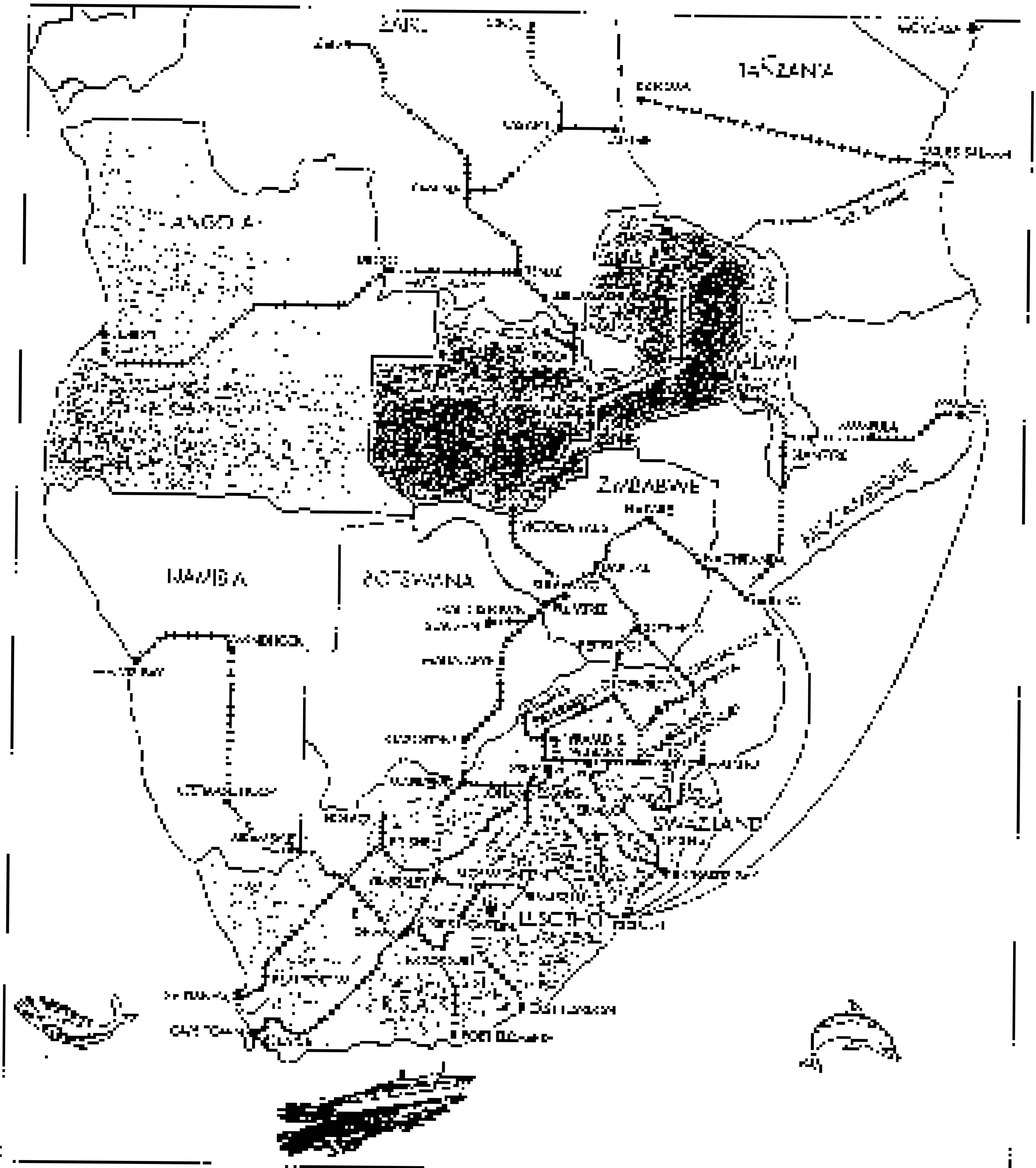
ANNEXURE A

SWAZILAND RAILWAY



SWAZILAND RAILWAY

Southern African Railways Network



ANNEXURE B

SWAZILAND RAILWAY

SAFETY HEALTH ENVIRONMENT POLICY

Its the policy of Swaziland Railway that its operations will be conducted in a manner that is Safe, Healthy and takes into consideration our natural environment. As integral parts of this policy Swaziland Railway believes that:-

- All injuries can be prevented.
- Management and employees at all levels are responsible for maintaining safe and healthy working conditions and preventing personal injuries and accidents.
- It is important to commit necessary resources to provide safer working conditions

Swaziland Railway undertakes to strive to achieve a situation where:

- All employees work in safe and healthful surroundings, clear and free of unsafe tools, equipment and behaviour. The first employee observing an unsafe tool, equipment, or behaviour immediately takes steps for correction.
- No employee knowingly takes risks that will cause injury or ill health to himself, his fellow employees or members of the general public or that will deplete or encourage the depletion of our natural environment.
- All employees consistently respect the rules and safe operating procedures that apply to their work.
- All accidents and injuries which occur during work are promptly reported to management, who takes immediate corrective action to identify to root cause so as to prevent re-occurrence.

Where there exists a conflict of interests, safety will take precedence over all other considerations.

Swaziland Railway is to continuously measure its S.H.E. performance by conducting audits.

Swaziland Railway will provide the necessary financial and human resources within limits to comply with the requirements of this policy.

No job is so important, No service is so Urgent, that we cannot take the time to perform all work safely.

G.J. Mahlalela
Chief Executive Officer

1 April 1995

NOTES

JOB BRIEFING GUIDELINES

Safety, Quality, and Productivity are the result of [illegible] job briefings.

STEP I. Plan the Job Briefing.

A. [illegible]
   1. Reviewing the work or task to be accomplished.
   2. Checking the job location and work area.
   3. [illegible] procedures.
   4. Determining tools, equipment and material requirements.
   5. Determining what rules, [illegible] procedures are applicable.

B. Consider existing and potential hazards that might be involved [illegible]
   1. Job and weather conditions.
   2. The [illegible] to be done.
   3. The job location.
   4. [illegible]
   5. Equipment [illegible]
   6. Traffic conditions and visibility.
   7. Time of day.
   8. Safety or personal protective equipment required.

C. Consider the work assignments to be made.
   1. Crew [illegible]
   2. Individual assignments.
   3. Abilities and experience of [illegible]

STEP II. Conduct the Job Briefing.

A. Explain work or task to employees.
   1. [illegible]
   2. Why it is to be done.
   3. What is to be done.
   4. Where it is to be done.
   5. How it is to be done.
   6. When it is done.
   7. What safety procedures are necessary.

B. Discuss existing or potential hazards and ways to eliminate or protect against them.

C. Make definite work assignments.
   1. Make sure employees understand assignments.
   2. Ask questions [illegible]

D. If special tools, materials, equipment or methods are used, make sure employees know how to proceed safely.

E. [illegible]

STEP III. Job Brief for Special Conditions.

A. Complex Jobs
   1. Brief only a portion of the job.
   2. Give additional briefing as the job progresses.

B. Change in job conditions — when it becomes necessary to change plans and procedures as the job progresses, brief employees on those changes. (For example: the weather condition changes.)

STEP IV. Follow up by Supervisor.

It is important that frequent checks be made as the job progresses to be sure that:
   1. Your plans are being followed [illegible]
   2. Each person is [illegible]
   3. Any changes [illegible]

STEP V. Individual Responsibility.

All employees are responsible to see that the work plan is carried out according to the Job Briefing [illegible] when conditions change.

ANNEXURE C

Safety Department

by [illegible] – Safety Manager

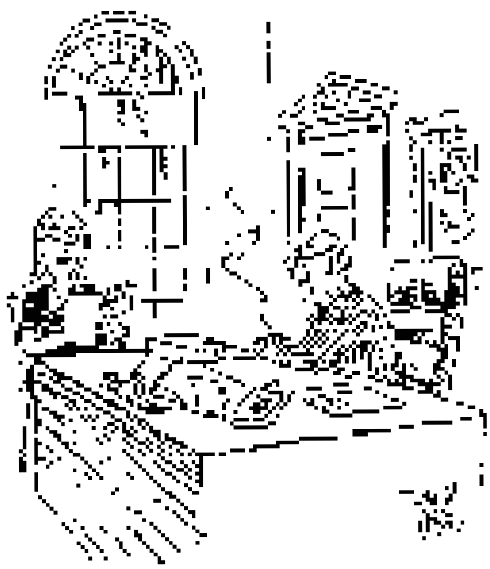
The Railway the Safe Way

It would be nice to remove the question mark from the above and read it without the question mark as a statement of fact.

The Swaziland Railway Safety Programme is about transforming this wish into pleasant reality. It is about making safe working and safety consciousness a habit of every railway employee. To try and achieve this, amongst other things, "Individual Safety Grading" has been introduced.

Individual Safety Grading

Employees involved in a certain task or profession draw up a guideline according to which they can be graded for safety performance each month. The guidelines are drawn by the people who perform the tasks because they are the best placed to know more about what constitutes safe working in their field.



Planning around a safety meeting at 9:15 [illegible] at 10:30 [illegible] at 11:30 Walking [illegible] at 1:00 Safety conference at 2:30 [illegible] meeting at 3:45 [illegible] at 4:30.

1. Achiever of the year: MR. MBONGENI SIMELANE
2. Achiever [illegible] of the year: MR. PETROS MANDLA HLATJWAKO

The winners won themselves the following each:

One [illegible]
One [illegible]
One pick axe with a handle
One Towel for Safety Champions' [illegible]

In addition to the above, the winners have their portraits mounted in their main office [illegible] list of honour (Achievers' Gallery).

The Track Section was about to complete a year of grading. We can expect to see some deserving souls winning themselves great prizes after the grading of the month for September 1996.

Band Wagon

The Individual Safety Grading band wagon has since been joined by the shunting personnel and the Carriage and Wagon Section (Diesel Shop).

Safety Tips

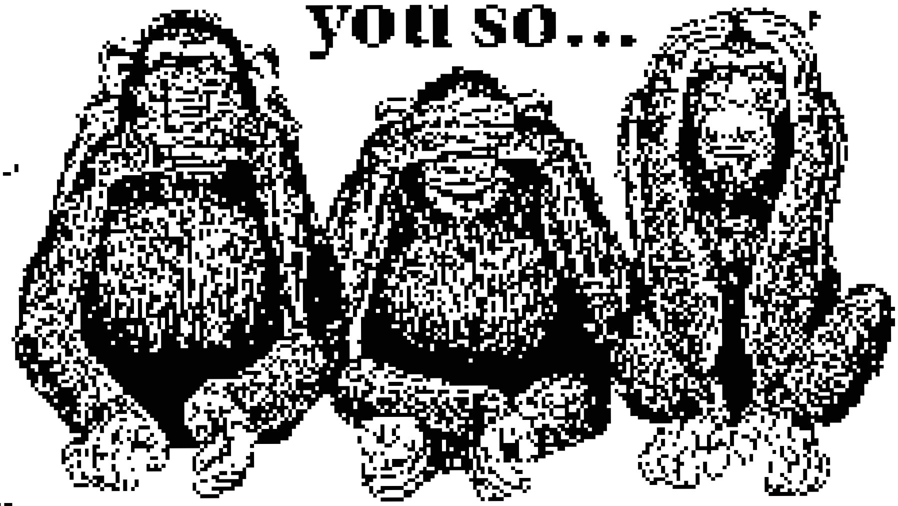
Avoid mixing diesel and washing powder as it results in an explosive mixture, dispose separately. Do not [illegible] equipment as it is so easy to [illegible]. Remember, we are more than [illegible]. ([illegible])

Avoid running electric cables under carpets. With constant walking [illegible] being pressed and moved around every day, insulation wears and one fine day, or night, your premises will be reduced to, God forbid, ashes.

Grading Update

The C & W Section was the first to take up the challenge of grading themselves and they have since been able to come up with achievers in the set up namely

We hate to say we told you so...



ANNEXURE D

DIRECTOR TRAFFIC

CASE STUDY -3

THE DISABLING INJURY ON DUTY OF MR. JABULANI DLAMINI PF 1849

After reading all the reports and interviewing witnesses concerning the injury of Mr Dlamini, I was finally able to find him at his house in Mobeni, Matsapha and interview him on Wednesday 31st of August 1996.

From the reports and the interviews the following scenario can be deducted.

Date :	27th March 1996
Time :	16:00 to 16:10 hrs (approx.)
Place:	Matsapha H Station

The shunting team of	Vusi Zwane	PF 1227	Driver
	Thulz Dlamini	PF 1524	Training asst
	Milford Dlamini	PF 1110	Leading Shunter
	Jabulani Dlamini	PF 1544	Shunter
	Sipho Dlamini	PF 1085	Yard master

is marshalling the load that will make up train No. 2706. The shunters have been communicating with the Yard Master and he informed them that loading had been completed at ICD and they were now pushing towards the line with the rolled crane to couple trucks for the load. Mr Jabulani Dlamini is allocated to [illegible] and the train is pushing slowly towards the trucks to be coupled.

Whilst the truck is pushing towards him Jabulani hears a sound like the mobile crane is loading whilst they have been informed that loading is over. He rushes to look from the West Side of the line before the oncoming train aiming to stop the train in case there is any imminent danger. Just then he trips on a piece of rail marking the clearance between the lines and falls forward towards the track. He does not reach the track but bumps against the first truck by his chest and rebounces [illegible] getting thrown forward towards the track and they slide straddling the first West Side wheel of the truck's first bogie.

Jabulani's left foot is slowly crushed by the first wheel but manages to pull out his right foot and attempts to pull out the left foot by bracing his right foot on the trucks body. By the time he extracts his left foot part of it has been crushed with his shoe which also got torn from his pulling.

Observations

1. Milford, the Leading Shunter was able to see his colleague going down and shouted instructions for the driver to stop immediately.

2. The Driver was able to stop relatively quickly. The footplate personnel were not able to see the unfolding of the incident since the train was on a curve.

3. The clearance mark that tripped the shunter was not flush with the surface of the yard as is normal, but was at an angle causing an obstruction by its length's edge. It transpired that the mark had all along been normal until some containers were derailed and were lying on their sides. The containers themselves did not disturb the clearance mark but it was disturbed by a pay loader which came to re-rail the boxes. When Per way was fixing the line the clearance mark was left in its now "up-raised" position. Jabu and claims that they reported this state of affairs several times to Per way.

4. My observation is that we still have an attitude problem about safety as people generally perceive it as a time waster until disaster strikes. The Shunters were probably reporting the clearance mark in passing and Per way people probably thought it was just unnecessary grumbling.

Crusade

Mr. Jabulani Dlamini agreed that there is an attitude problem. He said he was willing to address SR employees on the subject of Safety with his own experience to help deter a similar occurrence in the future. Mr. Dlamini will be taken to various Safety meetings as a guest speaker.

We at safety salute Mr. Dlamini on his courage, we are of the opinion that with him helping out the "attitude crusade" will be won.

WORKS AND ELECTRICAL MANAGER

THE INJURY OF MR. JOAM MAGONGO - PF1977

The Safety Unit did an investigation on the above mentioned accident after getting a report on the 7th of June 1996. Sitsakodve CEW personnel, witnesses and the victim were interviewed on the 10th June 1996. The injured employee also took the interviewer to the sight of the accident scene. The following scenario was derived from the above.

Date : 5th June 1996
Time : 11h30 (approx.)
Place : Sitsakodve Junior Village

Mr. Magongo and his workmates have been working on the power line next to the main road into the Junior Village since they left the depot early in the morning. What they have been doing exactly is mounting a cable into the posts through the insulator reels.

Mr. Magongo is an electrician by profession and his particular task in this assignment is to be up at the top from post to post slipping the cable into the groove in the insulator reel while the rest of his mates pull the cable from the ground through a loop hanging from other cables above. He has been doing the same task for about (4) posts when something suddenly goes wrong.

Mr. Magongo's left hand is under the cable being pulled by the gang on the ground. Suddenly some people who were doing something else join the pulling gang and the cable moves so fast through the loop and with so much force that it drags Mr. Magongo's hand and pinches into the insulator. Mr. Magongo is taken by surprise, he feels a sharp pain and when he looks at his left hand the tip of his index finger up to the beginning of the first joint is missing.

P.P.E

The first impression one gets is that this work should have been carried out using some kind of protective gloves. From the electricians one gathers that the gloves are not practical as they temper with the "grip" on such work.

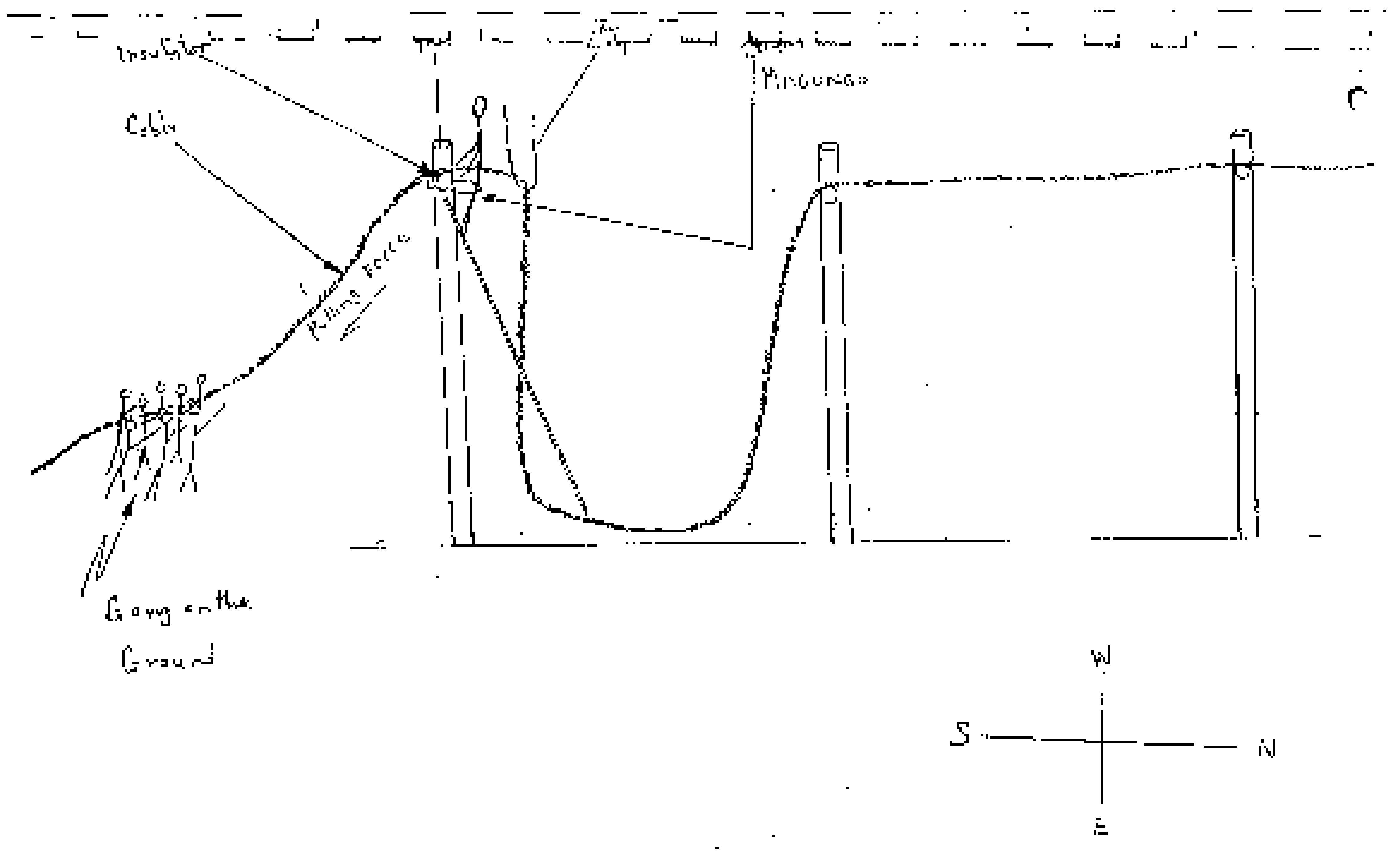
Job Briefing

The sudden extra force provided by some "extra" people without the notification of Mr. Magongo tells us that this work lacked proper planning and thorough briefing before commencement. This statement is not meant as a criticism for anyone as we are all aware that as an organisation we are still going through the safety learning process. The trick is to be prepared to verify. Page 33 of the Swaziland Safety Manual gives guidelines as the planning and conducting job briefings.

Find Annexures:

A Accident Scene Sketch
B Job Briefing Guidelines

This office would like to urge the electrical subsection to have elected representation in the Works Safety Committee. For details of this committees monthly meeting dates contact its secretary Mr.Bheki Makhanya PT 1474.


Insulator
Cable
Gang on the Ground
W
S
N
E

SWAZILAND RAILWAY

TO:- Asst. Director H.R.& D.
Swaziland Railway
MPAKA

ACCIDENT REPORT : MR. JOAH MAGONGO PF 1977

The employee referred above got injured and had one of the tip of his left hand finger cut off (i.e up to the first joint) while pulling a power line together with his workmates at Sidvokodvo.

This accident occurred at about 10h00 on Wednesday, 5/5/96.

According to a report received from one of the Nurses, the employee has been referred to Dr. Manners at Matsapha and treated at Nazarene Hospital. He was discharged on the same day.

Thank you.

M.C. [illegible]
PERSONNEL MANAGER

cc. Director H.R & D.
Safety Manager

HCM/jkk

SWAZILAND RAILWAY

ACCIDENT FORM

1. NAME OF INJURED EMPLOYEE: John ... Masuku ... [illegible]
2. DEPARTMENT: Engineering (Electrical Section)
3. OCCUPATION: Electrician
4. DATE AND TIME OF ACCIDENT: DATE: [illegible]/04/96 TIME: [illegible]
5. WHERE ACCIDENT OCCURRED: [illegible]
6. BRIEF DESCRIPTION OF ACCIDENT: He was on top of power line pole pulling a power line cable [illegible]
7. NATURE AND EXTENT OF INJURIES: [illegible]
8. NAMES OF WITNESSES: 1. [illegible] 2. [illegible]
9. REGION: [illegible] DIVISION: [illegible]
   DISTRICT: [illegible]
10. IMMEDIATE SUPERVISOR: [illegible]
11. GRADED TAX No.: [illegible]
12. SALARY: [illegible]
13. MARITAL STATE OF [illegible]: [illegible]
14. (a) NEXT OF KIN: [illegible]
    (b) ADDRESS: [illegible]

[signature]

Date: HEAD OF DEPARTMENT

International Rail Safety Conference

1996 CAPE TOWN

7 October - 9 October 1996
The Lord Charles Hotel, Cape Town, South Africa

Paper 9618

Dr Gerhard Booysen

An Integrated Risk Communication Strategy: A Spoornet Case Study

Publisher
2001 International Rail Safety Conference

CURRICULUM VITAE

Dr J G L Booysen

Degrees obtained include:

B.Com	-	Stellenbosch University
M.Com (Transport Economics)	-	Randse Afrikaanse Universiteit
D Com (Transport Economics)	-	Randse Afrikaanse Universiteit
Executive Development Programme	-	Wits Business School
Strategic Management Programme	-	Stellenbosch University

Dr Booysen has attended various National and International courses in the field of Insurance, Safety and Risk Management.

He has held managerial positions at Spoornet, a division of Transnet Limited, inter alia Regional Management and Executive Management at Spoornet Corporate Level.
Founder of the Risk Management Department of Spoornet in 1992.

Member of the Chartered Institute of Transport in Southern Africa, and is a Member of the SA Institute for Risk Managers (SAIRMA).

INTERNATIONAL RAILWAY SAFETY CONFERENCE

7 - 9 OCTOBER 96

SOMERSET-WEST, SOUTH AFRICA

INTEGRATED RISK COMMUNICATION STRATEGY

THE SPOORNET CASE STUDY

SYNOPSIS

This paper deals with the development of an Integrated Risk Communication strategy as developed by the Risk Management Department of Spoornet a division of Transnet Ltd. This strategy is an essential part of the total risk management process for a railway company. It is concluded that without a sound risk management process and communication strategy, railways will not be able to successfully execute their business strategies in order to be competitive in the 21 st century.

In a world of increased and accelerated change, the risks for companies are increasing at an alarming rate. *Informed* stakeholders will therefore assist in mitigating the risks threatening our survival.

Dr Gerhard Booysen

Assistant-General Manager(Risk Management)

Spoornet A Division Of Transnet Ltd

INTEGRATED RISK COMMUNICATION STRATEGY
THE SPOORNET CASE STUDY

1. INTRODUCTION

The purpose of this paper is to give you an overview of an Integrated Risk Communication strategy developed by the Risk Management department in Spoornet , the railway division of Transnet ltd.

I will briefly deal with the following issues:

- The rationale for an Integrated Risk Communication Strategy
- Integration of the Strategy with the risk management process in Spoornet
- Mission and objectives of the Risk Management Strategy
- Guiding principles
- The Risk Communication Process;and
- Risk Communication Strategy initiatives developed in terms of the above.

2. RATIONALE FOR AN INTEGRATED RISK COMMUNICATION STRATEGY

2.1 STRATEGIC BUSINESS CONSIDERATIONS

Spoornet, as many railway companies in the world, is repositioning itself to become a more market driven organisation.Business processes are being redesigned towards achieving the strategic objectives of the Division.

One of the core competencies that has been defined in Spoornet is Service Predictability to be operationally excellent. Service Predictability implies consistently and reliably conforming to customer requirements within acceptable cost.

Local and international market research confirmed reliability as the most important factor influencing freight transportation decisions. Globally businesses must demonstrate to an ever more demanding and less tolerant client base that they can provide a consistent and reliable level of quality in the goods and services they provide.

In view of this, it is evident that unmanaged risk will have a detrimental impact on business strategies.Businesses can often no longer survive the impact of unmanaged and unrecognised risks,nor can they afford to firefight the consequences of unmanaged risk.

2.2 SOCIAL IMPACT OF UNMANAGED RISK

As a responsible transporter of freight and passengers, Spoornet has a social responsibility towards all of its stakeholders.

Unmanaged risks lead to hardship being experienced by people affected by accidents.

It also impacts on the Corporate image of the company as perceived by the clients,employees and the general public.

In terms of the King Commission's report on Corporate Governance, directors of companies in South Africa are required to direct their reports to all stakeholders on matters of concern and interest to them.Society now expects greater accountability from companies in regard to their non-financial affairs, e.g. in relation to their employees and to the environment.

Risk materialisation therefore may hold grave consequences for a company if not managed in a responsible way.

2.3 LEGAL COMPLIANCE

Various acts in South Africa impose legal requirements to be complied with in the field of Safety, Health and the Environment. Strict compliance is required and we have seen action being taken in South Africa recently against directors of companies.

The Occupational Health and Safety Act in South Africa also gives the employer the duty to informe employees about risks and hazards in the workplace.

3. INTEGRATION OF THE STRATEGY WITH THE RISK MANAGEMENT PROCESS IN SPOORNET

In view of the above, Spoornet decided to internalise a world class risk management process which will visibly add value to its business strategies.

The mission is to develop strategies, systems, processes and programmes, in conjunction with line management and other relevant stakeholders, to create an integrated risk management process which will add value to Spoornet's business initiatives.

The Risk Communication Strategy was developed to support the long term goal of ensuring a culture of risk awareness in Spoornet and its stakeholders, through internal and external communication.

4. MISSION AND OBJECTIVES OF THE RISK COMMUNICATION STRATEGY

4.1 MISSION

The mission adopted read as follows:

"To sensitise and equip Spoornet's employees, through the medium of communication, to optimally deal with risk and to inform and educate the external stakeholders to deal with risks associated with rail in order to limit their exposure to risk."

External stakeholders include the general public,clients of Spoornet and vendors and contractors.

4.2 OBJECTIVES

Specific objectives flowing from the above are as follows:

- The promotion of an internal culture of risk awareness and prevention;
- Establishing a culture of ownership(asset protection) amongst employees. (This objective is also applicable to the external public with specific reference to rail fences and unauthorised rail crossings.)
- To establish an external culture of awareness to potential risk associated with rail and to limit their risk exposure; and
- To inform clients and contractors of the potential hazards associated with rail and to educate them in the correct handling of Spoornet's rail equipment.

The achievement of these objectives is facilitated by networking with other rail operators such as Metro Rail, the Department of Labour, the National Department for Education and other parastatals. The full support of line management is imperative.

5. PRINCIPLES IN THE DEVELOPMENT OF THE RISK COMMUNICATION STRATEGY

The following principles were adopted in the Development of the Risk Communication Strategy :

- Focus on the most important risk areas in Spoornet;
- Develop the strategy within the broader guidelines of the company's corporate communication guidelines;
- A long term view should be taken;
- Communication programmes should be aimed at specific target audiences;
- Results must be measured before next phases are introduced;
- Interpersonal communication should be supplemented with mass media exposure;
- Supporting activities such as seminars, training, publicity etc. should be exploited;
- Risk Communication strategies must be aligned with Predictable Service change management releases; and
- Risk communication programmes should be aligned with the Risk Management Business Plan initiatives.

6. THE RISK COMMUNICATION PROCESS IN PROGRAMME DEVELOPMENT

Programme development is facilitated by the following process which forms a closed loop: (See annexure 1)

- Identify most important risk areas to be addressed;
- Benchmark awareness levels;
- Summarise Balance Scorecard and establish gaps;
- Establish target audiences;

- Decide message;
- Decide on appropriate medium and or process;
- Develop media mechanism and apply; and
- Monitor the Programme efficiency and identify reviews necessary.

This process allows a focused development of risk communication programme initiatives.

7. RISK COMMUNICATION STRATEGY IMPLEMENTATION IN SPOORNET

The proof of the pudding is in the eating.Adopting the above approach, Spoornet developed and implemented the following programmes during the past 2 years:

- The successful implementation of an industrial theatre programme, sensitizing 25 000 employees at 100 different depots. Risk awareness levels increased from 12% before the programme to 54% after the programme;
- Spoornet in conjunction with Eskom ran an awareness campaign for clients working under overhead electricity.
- Spoornet launched a schools programme with a friendly character called Mr Choo-Choo to sensitise school children of risks involved near railway lines. The target market is all Primary schools in SA;
- A programme to create greater awareness of Rail Safety in general to Taxi Drivers, Taxi Commuters, Train Passengers by means of a Taxinet promotion;

- A stakeholder forum is being established with trade unions to facilitate transparency and participation in the development of safety,health and environmental policies and strategies;
- Safety week promotion;
- Poster awareness campaigns;
- Outdoor Billboards in marshalling yards with Safety slogans;
- A Health and Safety Induction course for all new employees at entry level; and
- Community awareness programmes, re illegal pedestrians on railway lines and Spoornet fences.

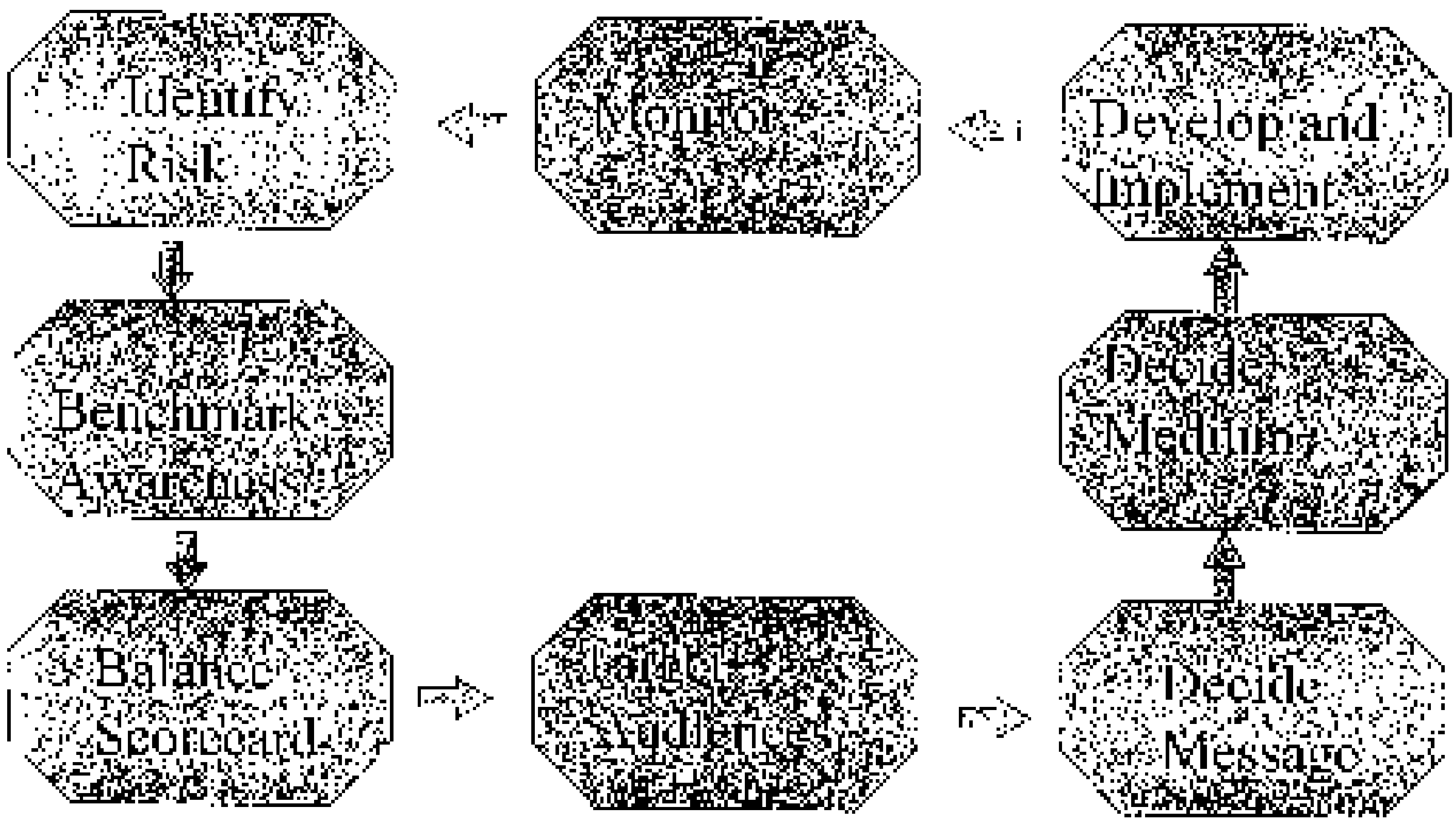
8. CONCLUSION

In this paper I dealt with the development of an Integrated Risk Communication strategy. I pointed out that this is an essential part in the total risk management process for a railway company. I submit that without a sound risk management process, railways will not be able to successfully execute their business strategies in order to be competitive in the 21 st century.

In a world of increased and accelerated change, the risks for companies are increasing at an alarming rate. *Informed* stakeholders through a well designed communication strategy will therefore assist in mitigating the risks threatening our very survival.

Risk Communication Process for Programme Development

Annexure 1



1996 CAPE TOWN

7 October - 9 October 1996
The Lord Charles Hotel, Cape Town, South Africa

Paper 9619

Tetsuro Aikawa
Masahiko Horiuchi

A Global Risk Assessment in East Japan Railway

CURRICULUM VITAE

Tetsuro Aikawa

Background:	Applied Mathematics
Professional Career:	*1972* Since Mr Aikawa entered Japanese National Railways, he has been mainly engaged in transport safety and technical R&D field as follows. • General manager of Transport Department (Mito Branch Office, Tohoku District, Head Office) • Manager of Transport Safety Department • Manager of Technical R&D Department *1996* Vice Director of Safety Research Laboratory also holds the post of General Manager of Technical R&D Department. Mr Aikawa has responsibility for management of the laboratory in reality.

A Global Risk Assessment

in

East Japan Railway

Tetsuro Aikawa
Masahiko Horiuchi

Safety Research Laboratory
East Japan Railway Company
2-2-6 Yoyogi Shibuya-ku Tokyo 151

October 7, 1996

Abstract

East Japan Railway (hereinafter JR East) is now trying to develop a risk assessment method which is suitable for the assessment of its own railway system for optimum decision making in safety management. This is a three year joint research project started in 1993 under a collaboration between Massachusetts Institute of Technology (hereinafter MIT) and JR East. By the year of 1996, which is the last year of the project, the authors have developed a basic method for the risk assessment, and now applying the method experimentally to the real field of JR East.

The idea of this risk assessment is based on that of probabilistic risk assessment (hereinafter PRA) which was proved to be useful in WASH-1400 to assess the risk of huge systems such as nuclear power plants. However, since the feature of railway systems is different from that of nuclear power plants in some ways, the authors have introduced some original ideas to the methods.

Although the authors have developed a basic method for the risk assessment, it might still need some improvement and/or adjustment according to the result of the experimental calculation, and then the risk of overall JR East will be evaluated in detail. As a progress report of the research, this paper describes some examples of the result of experimental calculation as well as the configuration of the method of the risk assessment in JR East.

1 Introduction

1.1 Background

Since the first inauguration of rail service in Japan in 1872, a great deal of efforts to improve the safety of railways have been expended more than 120 years. During the period, considerable improvement of safety has been reached by learning many lessons from experienced accidents

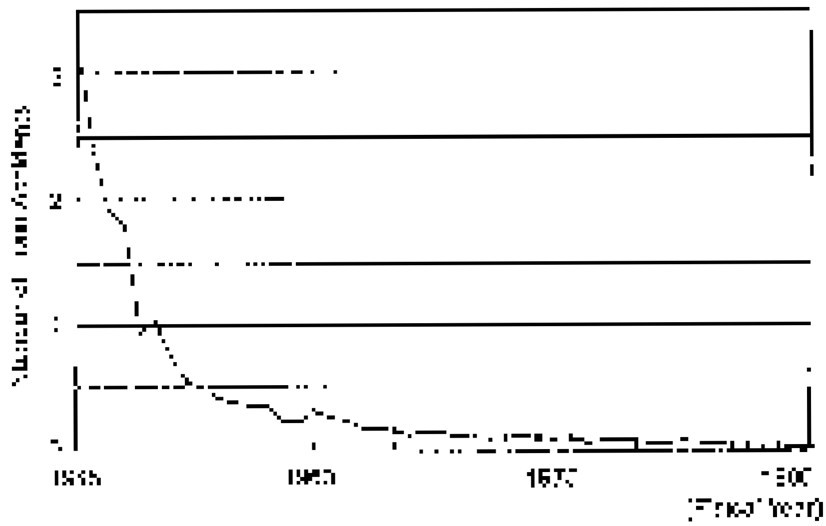


Figure 1 : Number of Train Accidents per Million Train Kilometers

Figure 1 shows the history of the number of train accidents per million train kilometers from 1945 to 1991 (Japanese National Railways before 1986, all JR lines after 1987). The definition of train accident in Japan is described in figure 4

There might be two possible interpretations of figure 1. One is that the safety of Japanese railway has been improved dramatically in the past forty-five years. The other is that the improvement rate of the safety is getting dull year by year.

As far as we try to improve the safety of the railway just empirically by learning from experienced accidents, the latter thing is inevitable, because as the safety level of the system becomes higher, the opportunity to meet accidents becomes rarer and rarer and it becomes more and more difficult to find lessons from actual accidents.

In addition, as the transportation volume becomes larger and the train speed becomes higher, the consequence of an accident tends to be larger and tend to exceed public acceptance. It means that we are not allowed to experience any accidents "to learn lessons" from them. In other words, in order to improve the safety of JR East, we have to find another way besides just learning from experienced accidents.

The PRA is considered to be one of the ways to achieve a breakthrough in such a situation of JR East.

1.2 Scope of the Research

Since a serious accident with a fatality (fatalities) might become a vital blow to the management of transportation company and to prevent such an accident is the most important matter in JR East, the authors attempt to estimate the number of fatalities due to various types of railway accidents in this risk assessment.

Describing the scope of the study in a PRA in detail is equivalent to listing the considered accident scenarios in the assessment. Thirty-four accident scenarios including internal causes (such as signal overruns, car failures, incorrect track maintenance, etc.) and external causes (such as falling rocks, earthquakes, collisions with automobiles running into tracks, etc.) are in consideration in this risk assessment. The accident scenarios are listed in Table 1.

Although the perceived risk by people might change with the cause of accident, magnitude of consequence, etc., neither risk perception nor risk aversion is not considered in this first step risk assessment.

2 Objective

Generally speaking, risk assessment is to answer the following questions [Kaplan and Garrick]:

1. What can go wrong that could lead to an outcome of hazard exposure?
2. How likely is this to happen?
3. If it happens, what consequences are expected?

The final goal of this research is to find optimum strategy for safety improvement of JR East. For decision making in safety management, it is helpful to know quantitatively how each kind of accident scenarios contributes to the total risk and how the risk is distributed in the system. Considering that, one of the expected outputs of this research is to derive such information on the present system of JR East by using PRA method.

Only once assessment, however, is not sufficient for the safety management of the railway, because the operational conditions and the environment of JR East keep changing without ceasing. Therefore, another expected output of this research is to establish the risk assessment method of JR East as a routine procedures so that we can repeat the assessment in a certain interval. To repeat the assessment is helpful for quantitative evaluation of effect of safety countermeasures which are being introduced to the system too.

As stated above, since the project is still on the way, only some examples of the result as well as the configuration of the method of the risk assessment in JR East are described in this paper.

3 Procedure of the Risk Assessment

The idea of the risk assessment of JR East is based on that of PRA which has been developed mainly in the field of nuclear power plant industry.

The general procedure of probabilistic risk assessment is:

1. to define risk and risk measurement unit
2. to list possible accident scenarios
3. to estimate probability of occurrence of accident due to each scenario
4. to estimate consequence of accident
5. to calculate the total risk by combining the estimated probabilities and the consequences

3.1 Definition of the Risk and Risk Measurement Unit

At the first step of the risk assessment procedure, to define "risk" and risk measurement unit is essential. Qualitatively speaking, risk can be defined as the potential of loss or injury resulting from exposure to a hazard [Modarres]. However, since quantitative definition is needed in this research, the authors use the following definition of risk as a simple and clear quantitative definition:

Risk is cost per unit time caused by hazardous event.

In terms of the cost, since the major interest of the authors is to prevent fatal accidents in JR East, loss of human (number of fatalities) is used as the unit of cost. It means that, in this research, neither property damage nor injury of people are considered to be cost in accident. Year is used as the unit of time. As the result, the risk we estimate in this research is the number of fatalities per year caused by railway accident in JR East.

3.2 Railway Accident Scenarios

Accident scenarios are set of descriptions of cause and consequence of each type of accident. In PRA, since any scenarios which are not listed here are never evaluated in the following procedures, as many as possible scenarios should be listed here. The total number of the scenarios, on the other hand, must be practically possible to be evaluated. Therefore, we must be careful not to omit any important scenarios while keeping the total number of the scenarios small.

One of the features of railway accident which makes it difficult to list the accident scenarios is that a same cause of accident can lead quite different consequences according to the circumstances of the accident. For example, an axle failure of a car may kill nobody if the train is running at low speed, running on flatlands, running with few people on board, while the same cause may kill many people if the train is at high speed, on a rail bridge, with a lot of people on board. For such a reason, if we try to list all the combinations of cause and consequences of railway accident as the scenarios of the risk assessment, the number of the scenarios would be almost infinite and to list the scenarios itself would become impossible.

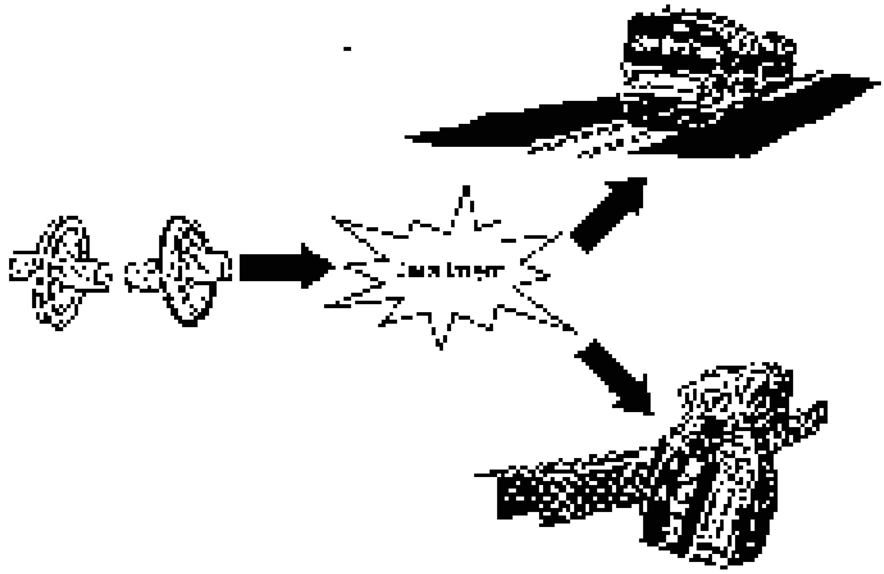


Figure 2 : Railway Accident Scenarios

In order to prevent such a problem, the authors have separated the scenarios into two parts, namely the cause part and the consequence part under the two assumptions as the following:

1. Almost all of the fatal railway accidents must be accompanied by collision or overturning.
2. Once a collision or a overturning happens, the consequence of the accident does not depend on the cause of the accident but depend on the circumstances of the accident.

Having above two assumptions, the authors were able to consider the cause part and the consequence part of the accident scenarios independently and were able to simplify the structure of the scenarios. Figure 3 shows the idea of the scenario simplification.

Although there are some fatal accident scenarios without overturning nor collision such as train fire, train separation, accidental door open, etc., the number of them are relatively small and the risk due to them can be calculated independently from other scenarios.

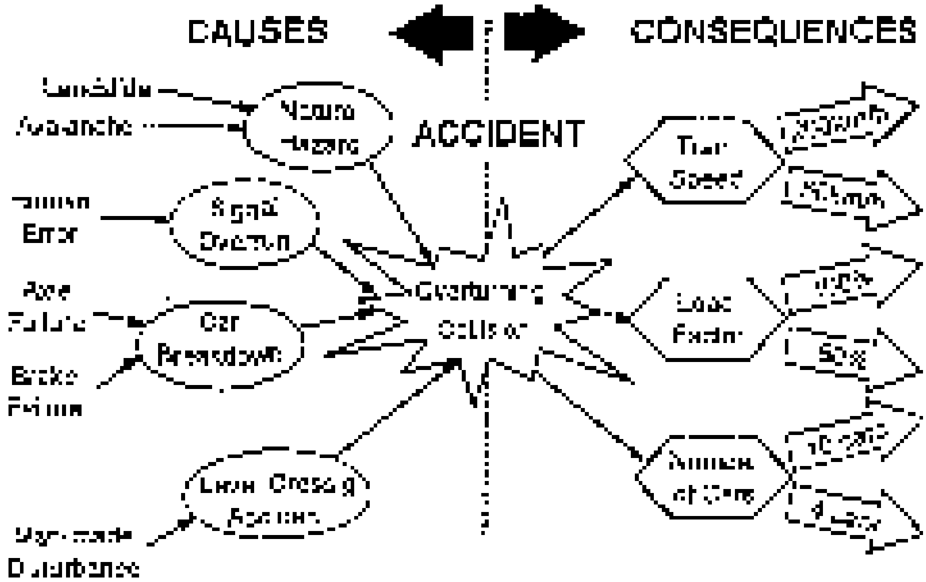


Figure 3.1 Simplification of Accident Scenarios

3.2.1 Accident Scenarios (Cause of Accident)

The cause part of the accident scenarios considered in this research are listed in table 1. The scenarios are listed by several experts of each field with reference to the data in the Accident/Incident Database in Safety Research Laboratory (see section 3.2.1). The total number of the considered scenarios (the cause part) is thirty-four.

3.2.2 Accident Scenarios (Consequence of Accident)

The consequence part of the accident scenarios considered in this research are not described in text style but in function style. The authors call them "Fatality Functions". Since the authors consider collision and overturning as the pivot events of the fatal rail accident scenarios, there are two fatality functions, namely, the Collision Fatality Function and the Overturning Fatality Function. The input parameters of the functions are speed of train, load factor, weight of obstacle, possible fall height of overturned cars, and the output of the functions are mortality.

The detail of the Fatality Functions is described in section 3.4.1.

3.3 Estimation of Occurrence Probability

The next step of the risk assessment is to estimate the occurrence probabilities of each accident scenario. In this research, since the scenarios are separated into two parts and they are connected with only two pivot events, the occurrence probabilities we have to estimate here are those of collision and overturning due to each cause scenario.

Table 1: Accident Scenarios considered in the Risk Assessment in JR East

1	Car Failure	Axle Failure
2		Bearing Failure
3		Insufficient Press Fit
4		Brake Failure
5		Power Control Failure
6		Parts Dropping
7		Train Separation
8	Signal System Failure	Incorrect Signal Indication
9		Incorrect Switching
10		Level Crossing Warning Device Failure
11		Train Protection System Failure
12	Signal Overrun	Signal Overrun
13	Natural Hazard	Track Bed Subsidence
14		Landslide
15		Scouring
16		Rock Fall
17		Fallen Trees
18		Avalanche
19		Strong Wind
20		Earthquake
21		Rail Sun Kink
22		Earth and Sand Avalanche
23	Incorrect Track Maintenance	Train Derailment at Simplified Switch for Maintenance Car
24		Train Collision with Track Maintenance Car (without driver)
25		Train Collision with Track Maintenance Car (with driver)
26		Insufficient Fastening between Crossties and Rails
27		Train Collision with Rail Changing Machines
28		Train Collision with Trolley
29	Error in Manual Signaling	Incorrect Blocking in Manual Signaling
30		Incorrect Routing in Manual Signaling
31	Man-made Disturbance	Collision with Automobile at Level Crossing
32		Collision with Automobile running into Track
33	Train Fire	Train Fire
34	Accidental Door Open	Accidental Door Open

In WASH-1400, the method used to estimate the occurrence probability was Event Tree Analysis. The authors once tried to apply the tree analysis to the estimation to find it difficult, because the paths to an accidental event are not so systematic and to determine the failure rate (or success rate) of each node is relatively difficult compare with a highly automated system such as nuclear power plant. On the other hand, since railway system has long history and many experiences of accidents/incidents, the data of them is relatively rich.

As the result of above argument, the authors estimated the occurrence probabilities based on the past accident/incident data instead of using tree analysis method.

3.3.1 Database in JR East

To estimate the occurrence probabilities of various types of accidents in this research, the data from a database in Safety Research Laboratory (hereinafter SRL) called 'Integrated Operational Accident/Incident Database' was used. The database stores the data of all accidents/incidents occurred after the establishment of JR East in 1987 and that of major accident in Japanese National Railways before 1987. The data is entered to the database by Transport Safety Division in each branch office every month following the Operational Accident Reporting Rule of JR East through an on-line computer system. The amount of the data is around one thousand per month. For this research, around seventy thousand accidents/incidents were referred.

The definitions of the accident and the incident in the Reporting Rule are shown in figure 4. The numbers following each item in figure 4 indicate the number of accidents/incidents entered the database in 1998(FY).

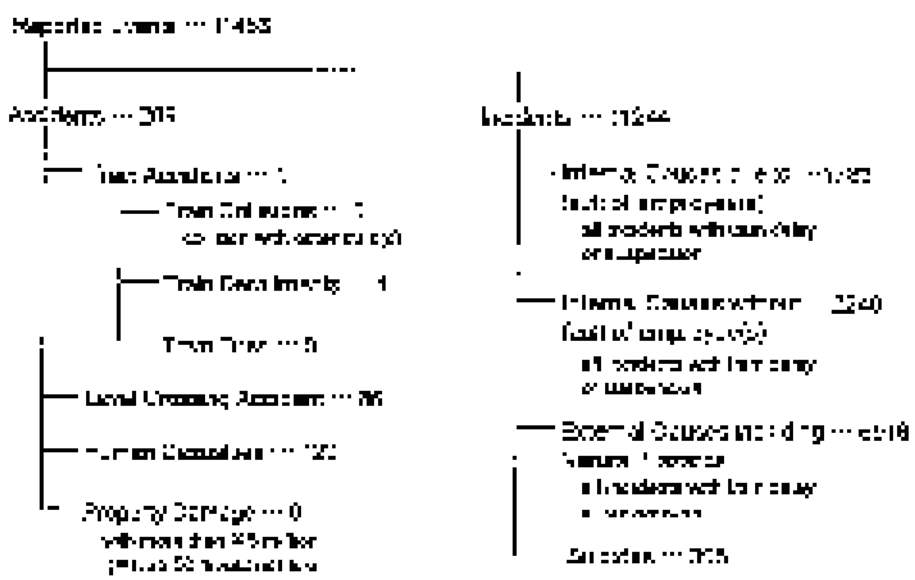


Figure 4 : The Definitions and the Breakdown of Accident/Incident in JR East

3.3.2 Classification into Subsystems

Given the accident data from the database, the average frequency of a certain type of accident can be obtained by dividing the number of the accidents by the number of the trials. For example, the average frequency of train collision accident due to signal overrun can be obtained by dividing the number of such accidents in a certain period by the number of the times trains pass signals in the same period. The obtained value is the first step estimation of the occurrence probability of such an accident.

The above mentioned calculation is, however, too crude for the purpose of the risk assessment, because the obtained occurrence probability does not reflect any difference of features of each part of JR East. In terms of signal violation, for example, such an estimation does not allow us to compare the safety between different types of train protection systems or to evaluate the effect of a new type train protection system.

In order to make the assessment accuracy higher and the significance evaluation possible, the authors have classified the JR East system into some subsystems according to the some attributes which effect the occurrence probabilities of the considered type of accident. Figure 5 shows the classification of the system for signal violation. In this case, JR East is classified into ten subsystems according to the attributes of track feature (single or double track), types of blocking systems, and types of train protection systems.

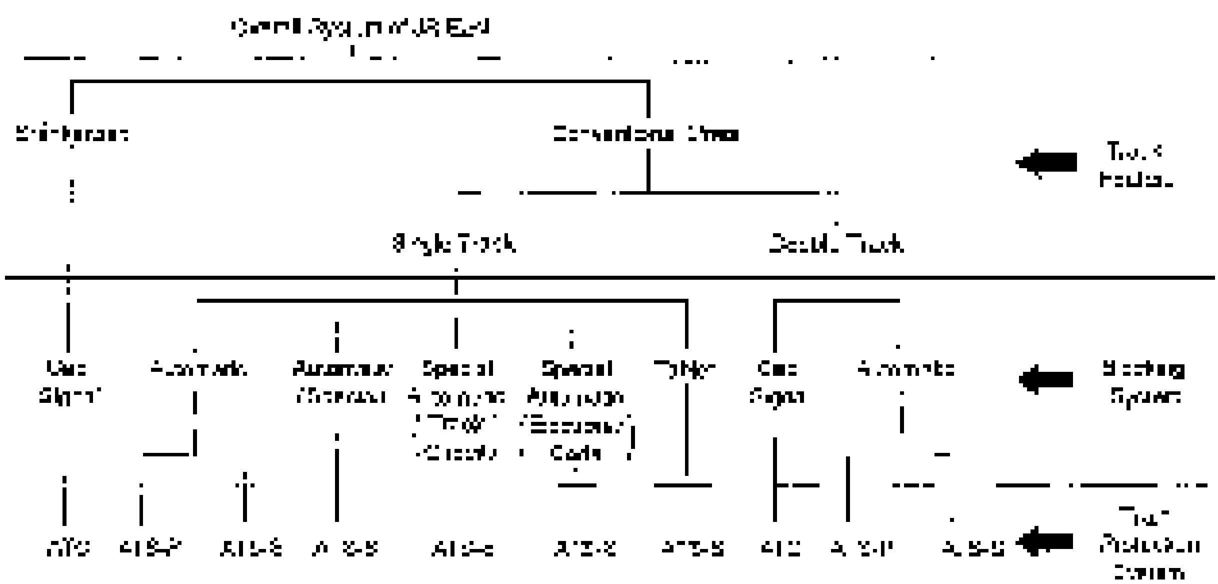


Figure 5 : Classification into Subsystems (Example of Signal Overrun)

The attributes for the classification should be major explanatory values for the occurrence probabilities of each accident scenario. In this research, however, since the authors have not found any deductive ways to find the major explanatory values for an event, the classification into subsystem was conducted subjectively by some experts in SRI.

Needless to say the classifications of the system can be different from scenario to scenario. The system classification for rock fall must be different from that for signal violation because the occurrence probability of rock fall must not depend on the blocking system of lines.

3.3.3 Estimation with no Accident Data

A typical problem in estimating the occurrence probabilities is that there are some scenarios with no actual accident data. Especially, after the classification of the system, this problem becomes pronounced because the number of the trials becomes smaller after the classification into subsystems. For such a subsystem, if we put zero as the numerator, the occurrence probability becomes zero and the subsystem is evaluated as a "perfect safe" system. Such an estimation would be nothing other than "learning from experienced accident".

Using the incident data in addition to the accident data is helpful to prevent the above problem, because, in most cases, some incidents have been observed in a subsystem even if there is no actual accident in the particular subsystem. In addition, estimation with much amount of data makes the estimation stable.

In using incident data as well as accident data, to estimate a conditional probability, that is the probability of the occurrence of an accident given an incident happens, is needed. The authors estimated this conditional probability by the following procedure.

1. Weight the observed incidents (if any accidents are observed, both of incidents and accidents) into some categories according to the likelihood of being an accident. The likelihood that an accident would be an accident is of course 1.
2. Obtain the total potential number of accidents by adding all of the weighted number of accidents/incidents in each accident scenario.
3. Fix the weight coefficient so that the total potential agrees with the observed number of accidents in each accident scenario.
4. Obtain the occurrence probability of accident in each subsystem by using the fixed weight coefficient.

3.4 Estimation of Consequence

Since we have separated the accident scenarios into the cause part and the consequence part and consider them independently, the assigned task here is to estimate the consequences of collision and overturning in various circumstances regardless of their cause.

3.4.1 Fatality Functions

For the above estimation, we have developed two functions so called the Collision Fatality Function and the Overturning Fatality Function.

As it is mentioned in section 3.2.2, the input parameters to the functions are speed of train, load factor, weight of obstacle, and possible fall height of overturned train and the output of them is mortality. Each function is a function in four dimensional space with three input parameters and one output. The shapes of these two functions have been fixed by combining the opinions of several members in SRT in the light of past serious railway accidents including those in Japanese National Railways and some overseas railways. Figure 6 is an example of the Fatality Functions.

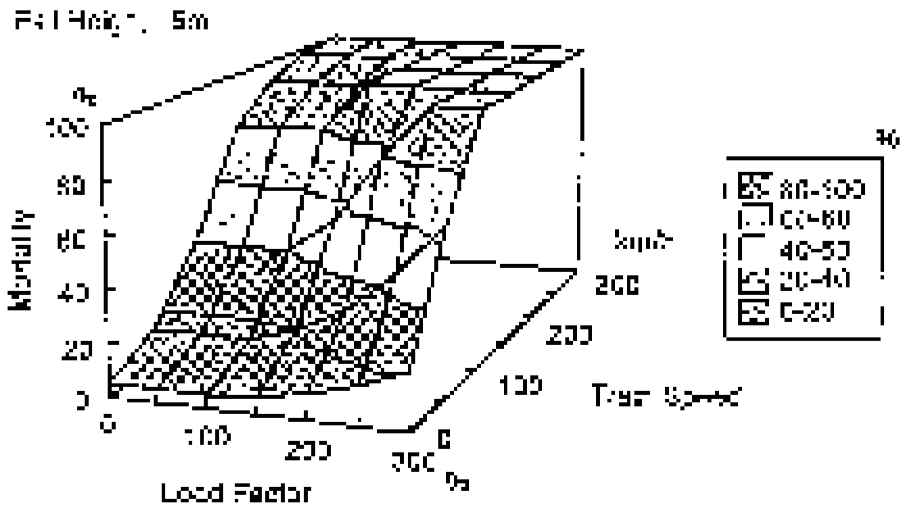


Figure 6 : Fatality Function (Overturning at Fall Height 5m)

3.5 Risk Distribution

In a broad way, the input parameters to the Fatality Functions are the functions of place, and the Fatality Functions themselves are the functions of place, too. Therefore, by obtaining the occurrence probabilities of collision and overturning due to each cause scenarios at each place of JR East, the risk distribution in JR East can be obtained by combining them with the Fatality Functions. The authors' original attempt was to calculate the risk in every 500m on the lines of JR East.

Since the occurrence probability of accident per trial in each subsystem due to each cause scenario has been obtained in section 3.3, what is needed here is to count the number of trials in every 500m section on JR East lines for each subsystem of each cause scenario. Figure 7 shows the idea of the heaping in every 500m section.

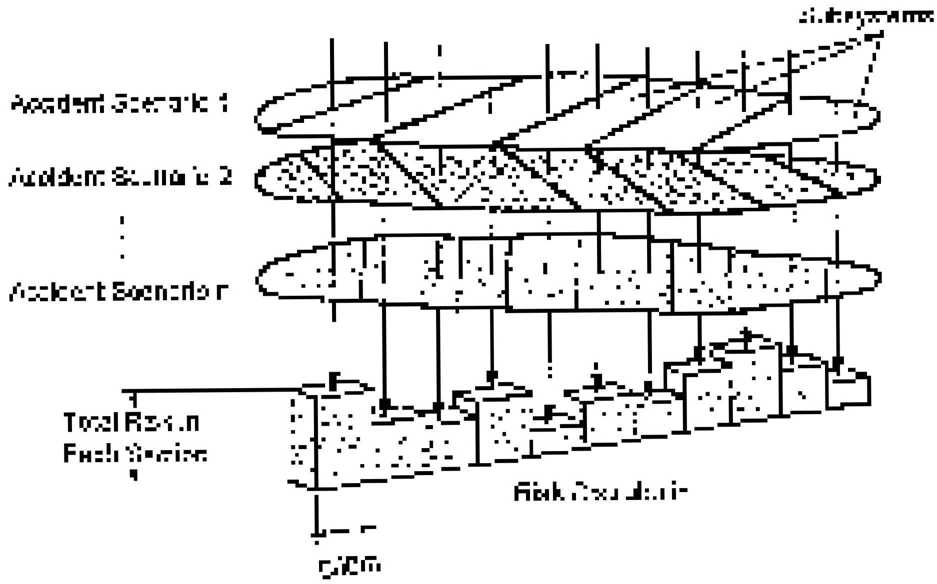


Figure 7 Risk Reading in every 500m Section

4 Examples of the Result

The authors have applied the above risk assessment procedures experimentally to one of the real lines in JR East (Chuo Line between Tokyo and Kofu 132km). About the half of the line (between Tokyo and Takao 53km) is a typical commuter line with heavy traffic volume (650 trains per day) and the rest of it is a suburb line (180 trains per day) in mountainous area. JR East has introduced a new type train protection system (ATS-P) between Tokyo and Takao to improve the safety of the line. The train protection system between Takao and Kofu is still conventional type (ATS-S). Figure 8 is a map of the line.

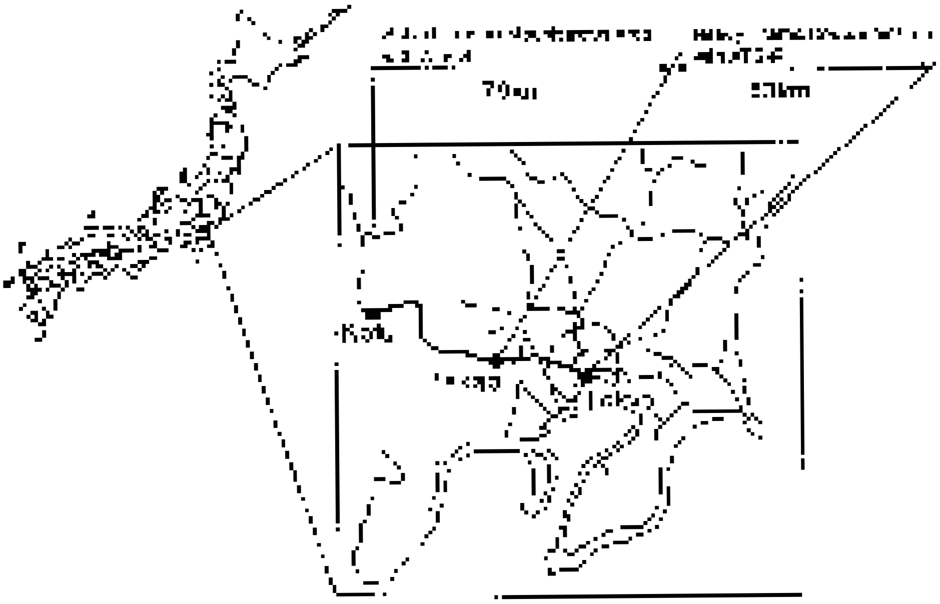


Figure 8 : Chuo Line

4.1 Risk Distribution on Chuo Line

Figure 9 shows the risk distribution in every 500m on Chuo Line at the present time. According to the experimental calculation, the total risk on this line is 2.28×10^{-2} persons/year.

4.2 Breakdowns of the Risk on Chuo Line

Figure 10 shows the breakdowns of the risk on Chuo Line. The graphs tell us how much each type of accident (each accident scenario) contributes to the total risk of the particular line. The difference between the graph 1 (Tokyo-Takao) and the graph 2 (Takao-Kofu) reflects the difference of the features of each section.

4.3 Quantitative Evaluation of New Train Protection System (ATS-P)

The authors have calculated the safety improvement effect of ATS-P, which is a new type train protection system being introduced at JR East from 1988. On Chuo Line, ATS-P has been installed between Toky and Takao, but has not yet between Takao and Kofu.

Figure 11 shows the risk distributions between Tokyo and Kofu with and without ATS-P between Tokyo and Takao. The distribution with ATS-P is the same as that in Figure 9. Note that the vertical axis scale in Figure 11 is different from that in Figure 9. The difference between the distributions (with and without ATS-P) is the safety improvement effect of ATS-P on Chuo Line. According to the authors' calculation, the risk on Chuo Line has been reduced by 0.25 persons/year by ATS-P.

Figure 12 shows the same distributions with and without ATS-P between Takao and Kofu. This is a kind of simulation of a future safety investment. The result is that the risk would be reduced by 0.035 persons/year by installing ATS-P between Takao and Kofu.

The major reasons of the difference of the ATS-P effect are difference of the train density and station intervals. The result supports that to have introduced ATS-P between Tokyo and Takao as a first step was an appropriate decision making.

5 Conclusion

The authors have developed a basic method of the risk assessment which is suitable for the assessment of JR East. Also, the authors have applied the method to a part of JR East experimentally.

The result of the experimental calculation indicates that the developed method is useful for the assessment of the railway system.

Problems to be solved which was found through the experimental calculation are:

- Risk calculation in every 500m would need too much labor and time to cover overall JR East even after the establishment of a routine calculation procedure.

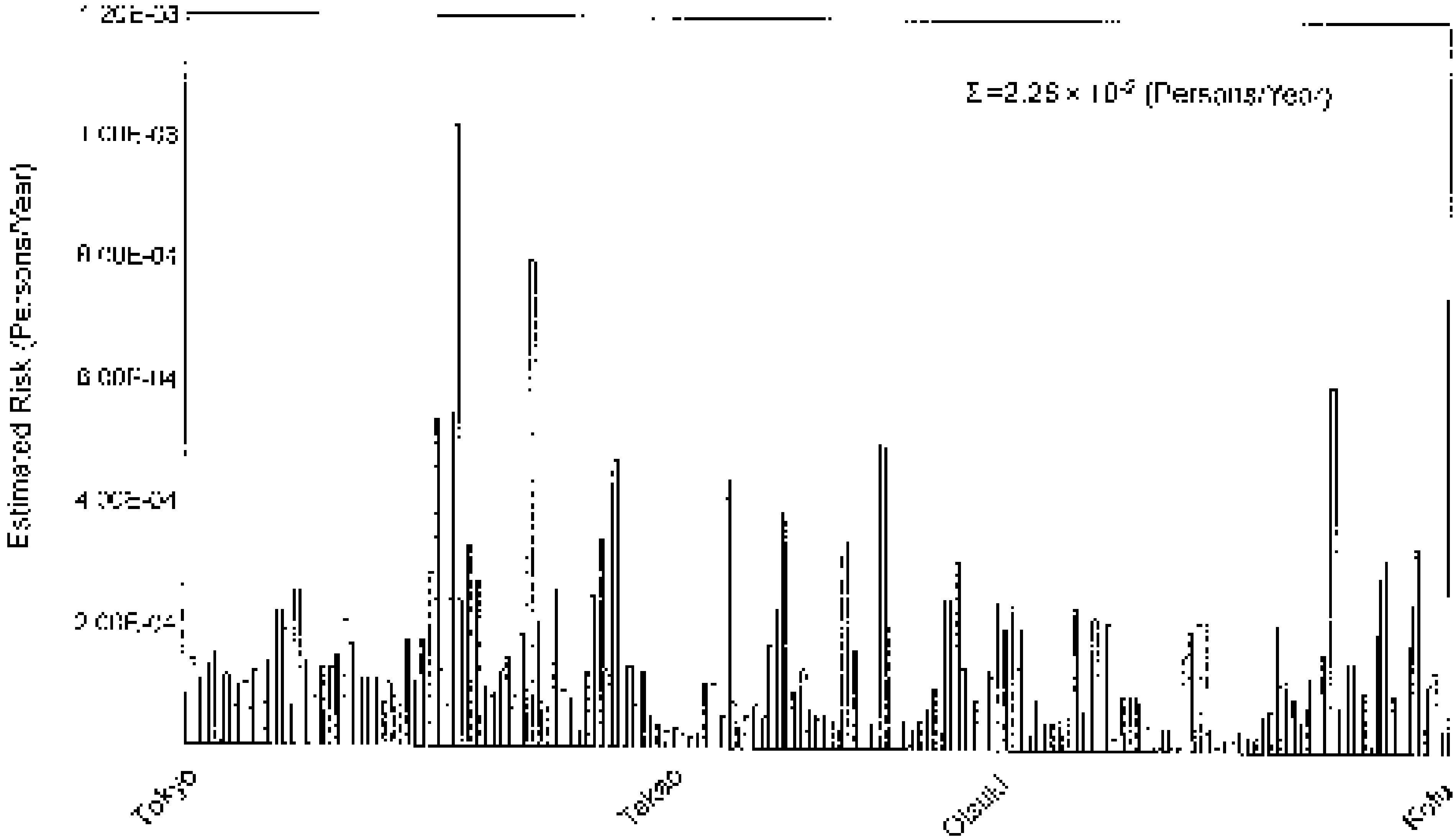


Figure 9 : Risk Distribution on Chuo Line (Present)

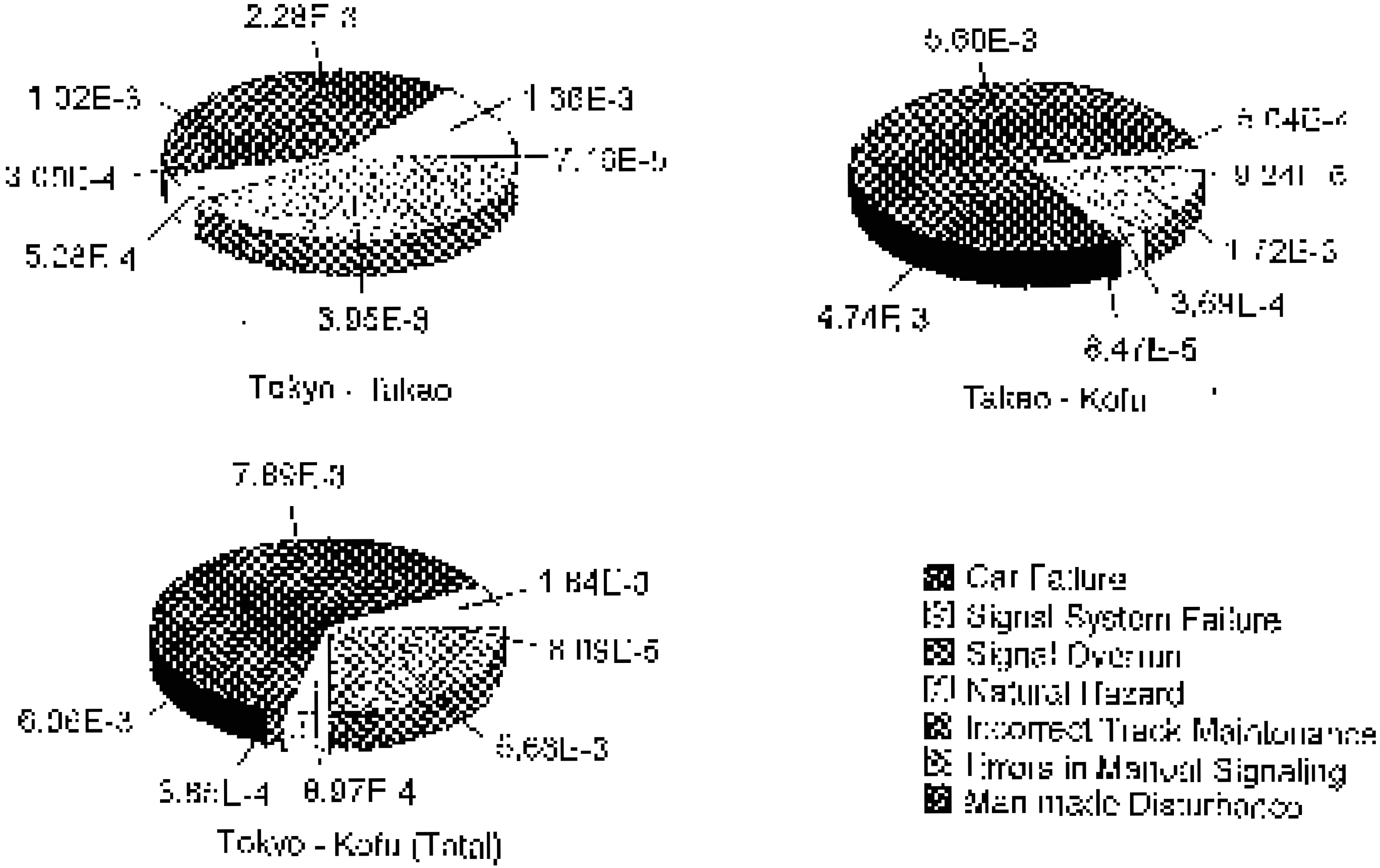


Figure 10 : Risk Breakdowns on Chuo Line (Unit : Persons/Year)

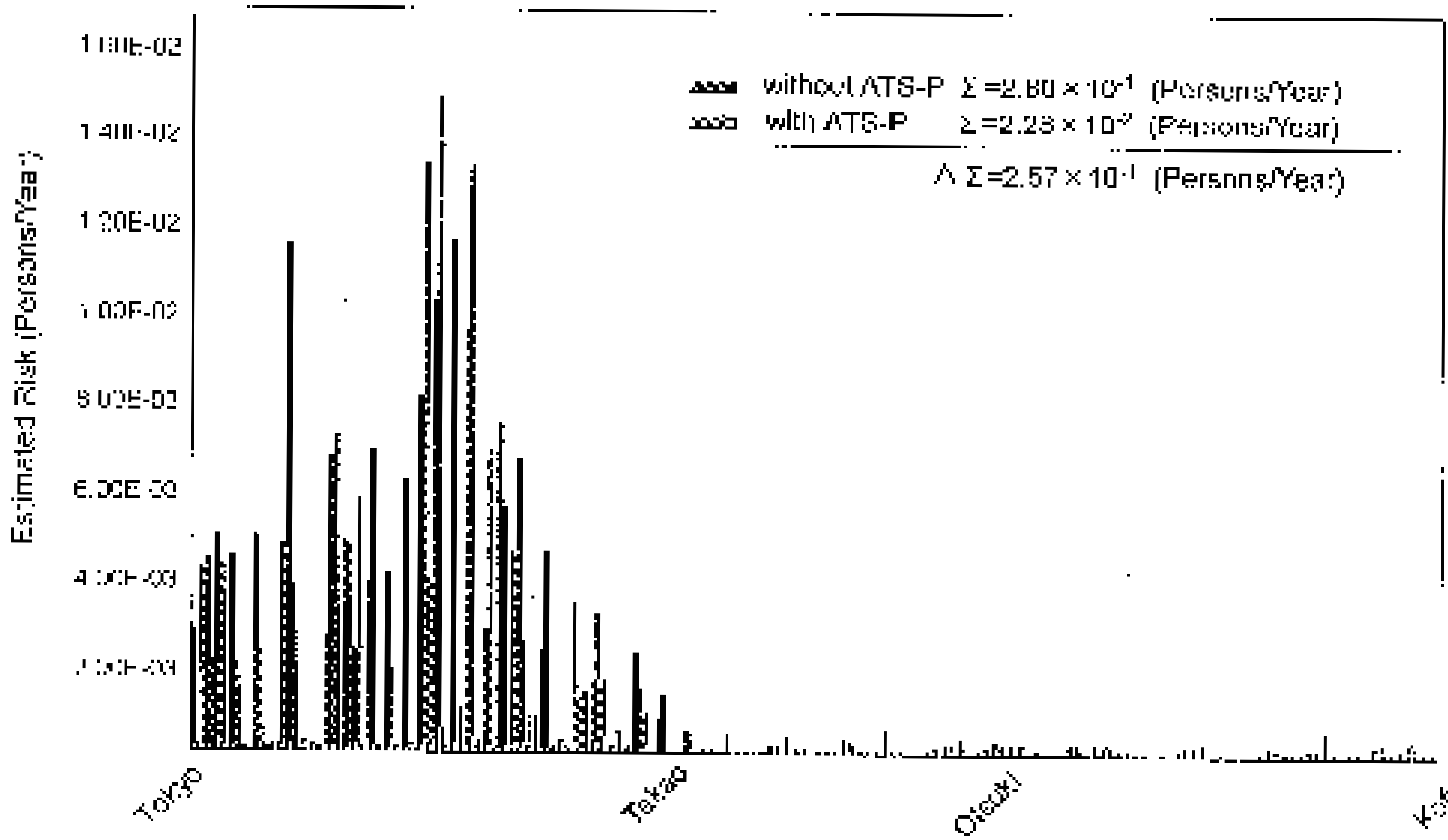


Figure 11 Risk Distribution with/without ATS-P between Tokyo and Takao

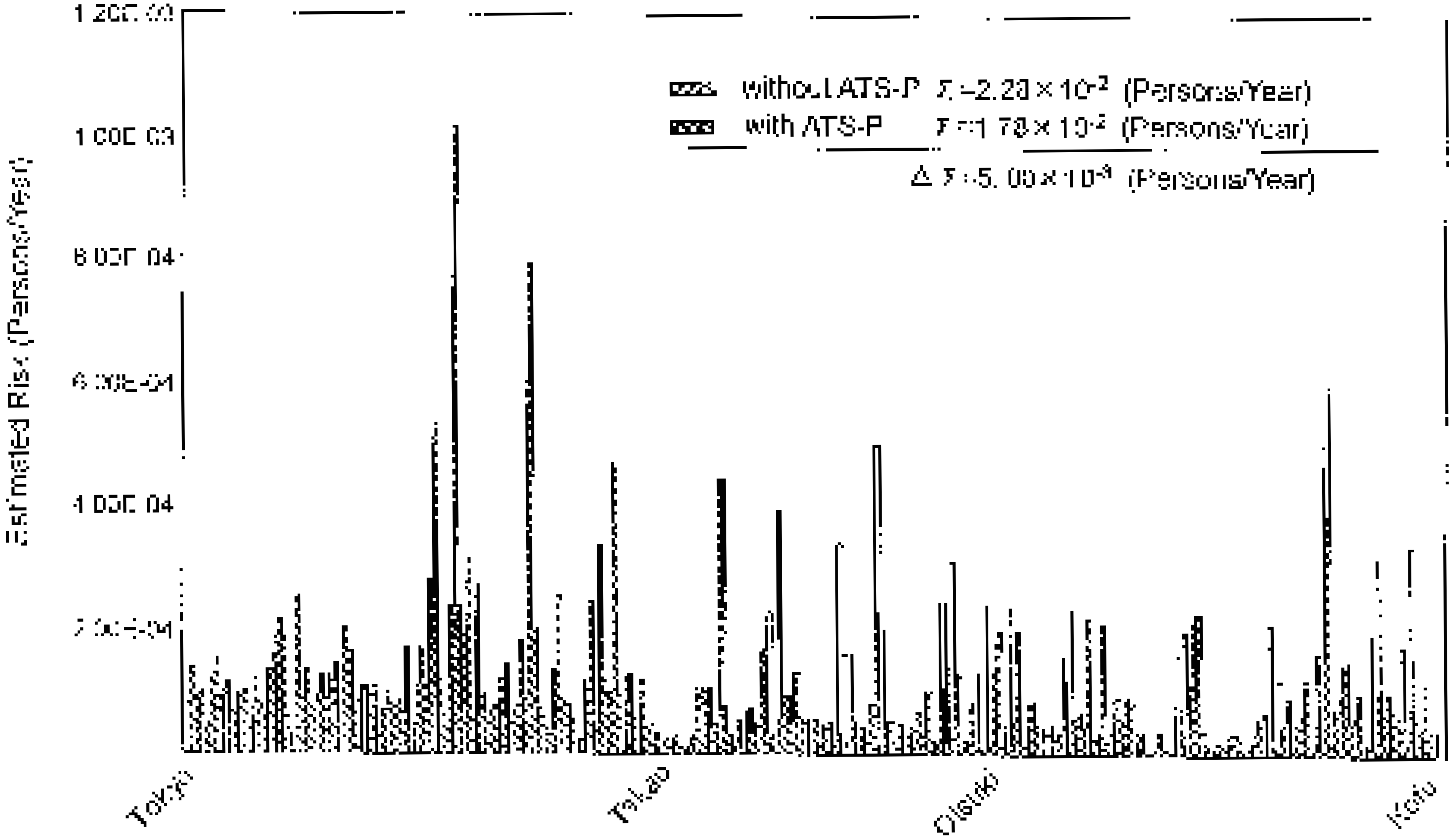


Figure 12 : Risk Distribution with/without ATS-P between Takao and Kofu

2. The estimation tends to be too much pessimistic. Although pessimistic estimation might be better than optimistic estimation as an assessment by the interested party, it still needs improvement.
3. Since the global risk assessment covers various field and should involve many experts as a member of the project, and also the method includes some subjective judgments, the idea of quality control is needed for homogeneous data quality.

6 Future Work

The authors are now calculating overall risk of JR East. In that process, we attempt to improve the accuracy of the assessment by comparing the estimated total risk and observed total risk back and forth. After some trial, we will obtain a reasonable result and it will give us some helpful suggestions to find the most appropriate way to improve the safety of JR East.

As the first step risk assessment, JR East has been classified into some subsystem focusing on hardware in each accidents, however, in order to make it possible to evaluate the risk from various point of view such as human factors, the classification of the system needs to be varied in the future.

In addition to that, the procedure and the mathematical models applied in this risk assessment need to be improved continuously. As far as the challenge to safety improvement is an eternal assignment for railway people, the risk assessment needs to be improved forever, too.

1996 CAPE TOWN

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The Lord Charles Hotel, Cape Town, South Africa

Paper 9620

Satoshi Nakai

Promoting Safety through Exchange of Opinions Between Top Management and Field Personnel - General Safety Inspections

CURRICULUM VITAE

Satoshi Nakai

Satoshi Nakai joined the Japanese National Railways in 1975, before the national railway organisation was re-organised into twelve organisations including East Japan Railway Company.

He has spent several years in quality control and production management at rolling stock maintenance workshops. After that, he has been working mainly in administration of rolling stock and transportation departments.

At present, he is in charge of safety management of railway operations in general. His most important tasks include company-wide improvement of systems to prevent train collisions and establishment of countermeasures against accidents during maintenance works involving casualties to maintenance personnel hit by a train or collisions of maintenance vehicles with a train.

Promoting Safety through Exchange of Opinions Between Top Management and Field Personnel - General Safety Inspections -

Satoshi Nakai, Manager

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East Japan Railway Company

1-6-5, Marunouchi, Chiyoda-ku, Tokyo 100, Japan

October 7-9, 1996

1. Transport Safety Concept, East Japan Railway Company

Our firm was established following the division and privatization of the Japanese National Railways in 1987. During the nine years that have passed since that time, the providing of safe railway transportation has been given top priority by management, and efforts have been made to improve the level of safety. The basic philosophy behind those efforts is as summarized below.

(1) Improvement of safety equipment in both importance and effectiveness, and promotion of systemization.

(2) Emphasis on each employee dealing with safety both autonomously and spontaneously

(3) Implementation of an organization that places safety first.

(4) Effective accommodation of changes in the environment surrounding railways.

This philosophy serves to define the level of safety. Various measures have been implemented from the following aspects:

- The philosophy and mode of behavior of the organization and its personnel
- The provision of signals and other safety equipment and systems, along with appropriate regulations

As a concrete example of this philosophy, roughly 1/3 of the total annual equipment investment made by our company, equal to roughly 600 million to 1 billion dollars, is allocated for investment in measures for preventing train collisions and safety factors such as those relating to rolling stock replacement.

In addition, in respecting the spontaneity of each of our employees, we promote activities that enable employees engaged in field work to improve our level of safety. We refer to these as "Challenge Safety" activities. We have also been engaged in various other activities that are based on a common awareness of safety by both the organization and individuals.

One of these activities that will be introduced here is the "Promoting Safety through Exchange of Opinions between Top Management and Field Personnel" - what we refer to as our "General Safety Inspections".

2. "General Safety Inspections"

(1) What are "General Safety Inspections"?

Our company is engaged in providing service to customers through the operation of trains, in the form of an organization consisting of our company headquarters, branch offices and field agencies.

For both safety and service, whether or not they are implemented reliably and satisfactory results are achieved is dependent upon field agencies engaged in the actual operation of trains and related duties. In addition, numerous ideas for increasing the level of safety and implementing improvements for providing better service are also initiated in the field.

Consequently, we emphasize field operations within the framework of our management activities, listening closely to the opinions of our employees to gain an accurate understanding of field work and reflect those opinions in our policies.

"General Safety Inspections" are conducted based on that philosophy.

<u>Contents of "General Safety Inspections"</u>

- Each year, a different theme is selected. Themes are chosen in consideration of the circumstances of accidents or malfunctions at that time, the status of progress of safety policies and so forth.
- Nearly all directors, including the president, participate in these general safety inspections. These directors move around to several field sites over the course of 2 days in groups of 3-4 each with other members of

top management. Participants from the company headquarters normally consist of more than 100 persons comprising roughly 30 groups.

- At each field site, in addition to observing the manner in which operations are conducted, members of the groups exchange opinions with employees working there regarding their daily work.

  Opinions are exchanged not only with supervisors, but also with operators, maintenance personnel and other employees engaged in actual operations. This is done because the persons who are the most familiar with field operations and who play a leading role in ensuring safety are actual employees working at the sites.

  Opinion exchange primarily focuses on a predetermined theme, but employees are also encouraged to speak freely about other subjects as well.

  Members from the company headquarters reply to the opinions that have been expressed as well as convey the manner of thinking of the headquarters.

- In addition to each group gathering information on field status and the opinions expressed there, and then outlining this to staff members of branch offices in charge of the field sites, discussions are also held on the causes of problems and ways to make improvements in the future.

- The contents of the discussions held at each field site and branch office are brought back to the company headquarters where they are further discussed and studied at the company headquarters as well. As a result, whether improvements are to be implemented immediately, the present situation is to be left unchanged or further studies are to be made, the manner in which each subject is to be handled in the future is clearly indicated, and each branch office is informed of that result along with the reasons for it. Branch offices then inform field personnel affected by that result and convey the result to employees that attended the opinion exchange.

- Those matters that require additional study at the company headquarters are handled by forming a study team that is involved in the analysis of the situation and examination of countermeasures, and is also responsible for preparing a countermeasures execution schedule. This execution schedule is implemented by resolution of the board of directors as necessary.

Fig. 1 is a schematic explanation of this process.

(2) Objectives

The objectives of "General Safety Inspections" are as follows

1) To gain an accurate understanding of the actual situation in the field

2) To deepen mutual understanding between the company headquarters and field personnel

3) To promote prompt resolution of problems

(3) Characteristics

These "General Safety Inspections" have the following characteristics.

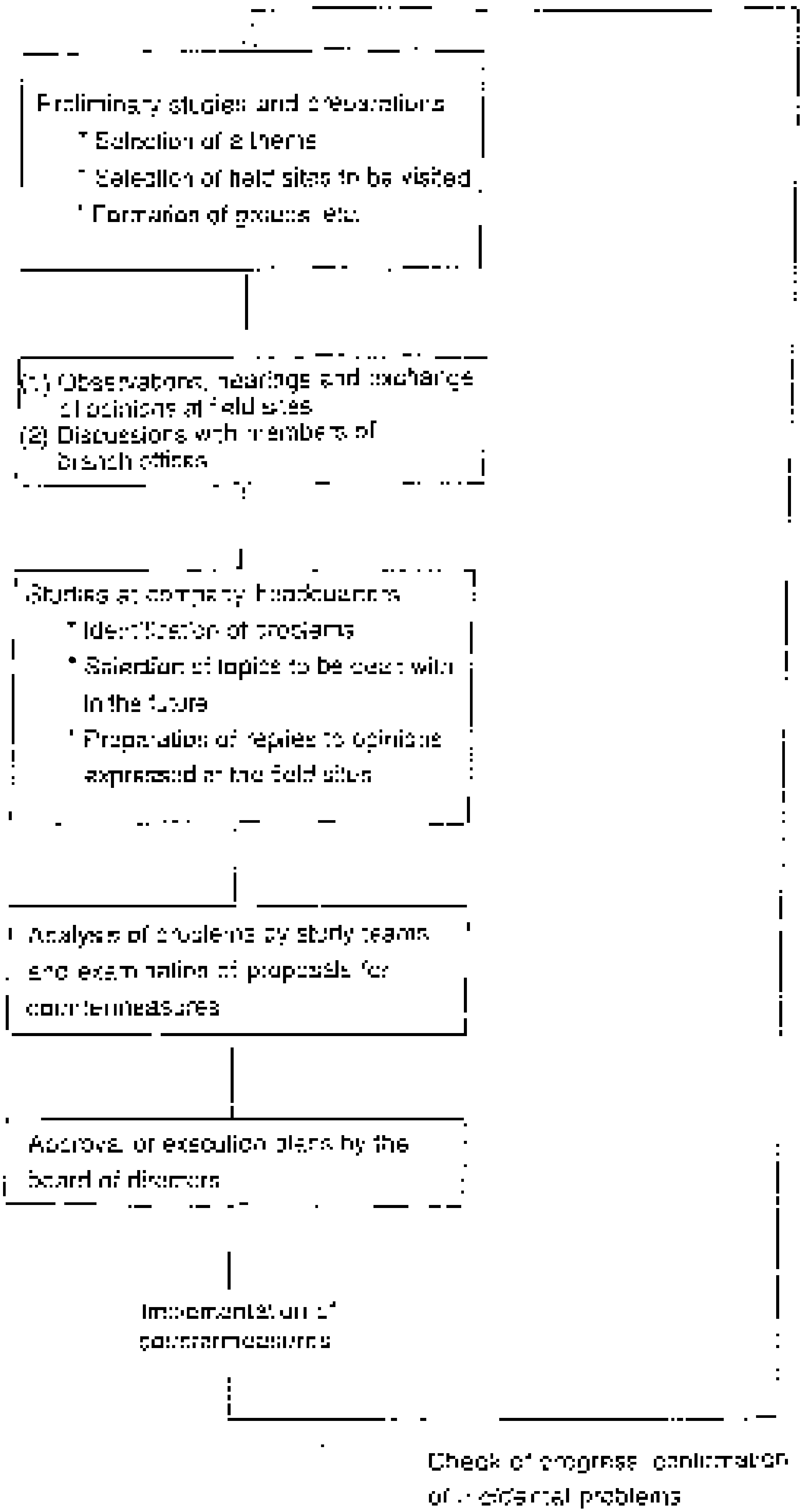

Fig. 1 Flow Chart for Conducting "General Safety Inspections"

- All directors from the company headquarters, from the president on down, are able to observe operations in the field, listen to the opinions of field personnel and discuss issues directly with field personnel.
- Discussions are held freely. Naturally, the company's direction and policies are also subject to criticism.
- These are not inspections in the true sense. As such, inspection items are not established.
- The activities have no direct effect on the evaluation of field agencies or their supervisors.
- There are cases in which topics or countermeasures established as a result of going through the examination process may be implemented over the course of several years.

(4) Positioning within Safety Activities

The positioning of "General Safety Inspections" within the overall safety activities deployed by our company is as shown in Fig. 2. General safety inspections are one of the most significant activities among our regular activities and events, and our safety division pours considerable enthusiasm into holding them each year.

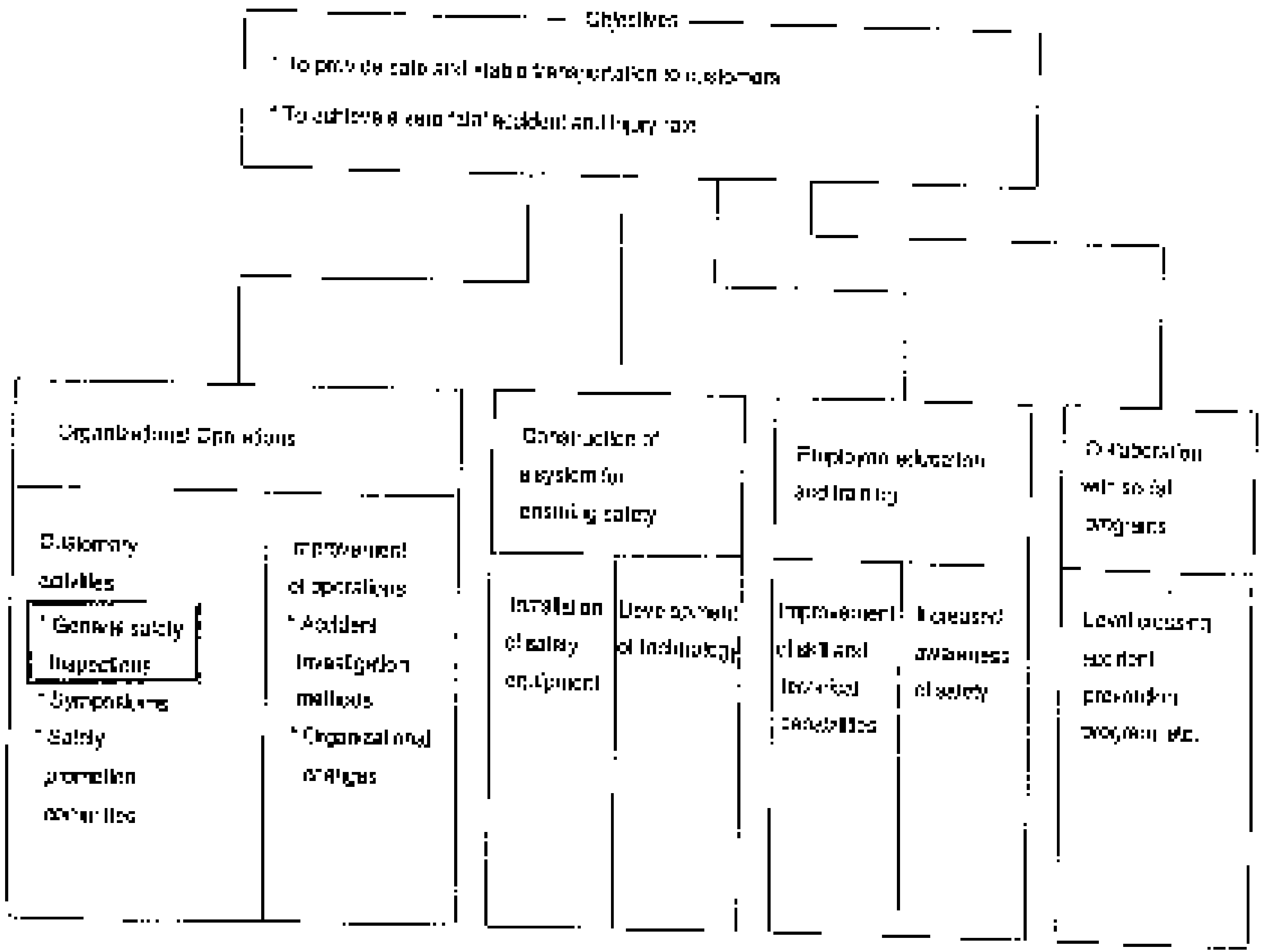

Fig. 2 Safety Activities of East Japan Railway Company

(3) Reason for Beginning "General Safety Inspections"

When our firm was established in 1987 following the division and privatization of the Japan National Railways, we were forced to start under the worst conditions, including restrictions on investment and obsolete equipment due to the difficult financial situation. In order to obtain the trust of customers in terms of providing a safe and comfortable means of transportation, safety was set as the most important management policy and various efforts were made to ensure that safety. More specifically, after an accident occurred, instead of adopting countermeasures for that specific accident, priority was placed on safety measures to prevent future accidents. Efforts were made that focused on determination of cause instead of determination of liability. Instead of taking uniform measures that apply throughout the company, detailed actions were taken that take into consideration the characteristics of individual lines. Moreover, efforts were made to achieve unification between management and labor to promote the creation of a common awareness.

Despite these efforts, a series of accidents occurred that had a major impact on our company, including a train fire in March 1988, the derailment and overturning of a freight train after the tracks were washed out by flooding of the river below the tracks in August, and the derailment of a freight train, its separation and subsequent collision with another freight train in October. Various discussions were held to determine the causes and examine countermeasures. During the course of these discussions, numerous questions were raised, including whether or not problems or desires of field personnel were being adequately conveyed to the company headquarters, whether or not the company headquarters had an accurate understanding of the actual situation in the field, and whether or not policies of the company headquarters were being conveyed to employees in the field. The conclusion was therefore reached that it would be necessary to actually observe operations in the field, listen to the opinions of field personnel and hold discussions with them. Thus, in addition to preventing the recurrence of similar accidents, it was decided to implement "General Safety Inspections" in order to investigate the status of overall safety efforts in the field, determine any problems and reflect those findings in the safety policies of the company headquarters, the first round of which were held in November 1986.

(9) Events from the 1st Round to the 2nd Round of "General Safety Inspections"

During the first holding of "General Safety Inspections", the president and other members of top management from the company headquarters divided into groups and went out to visit roughly 80 field agencies. They observed the status of each field agency and discussed opinions regarding work performed and other related matters directly with employees. Although there were doubts in the beginning as to whether or not employees would actually state their true feelings in front of top management, valuable opinions were expressed that helped top management get a good understanding of the thoughts of field personnel. There were many opinions expressed regarding investigation of incidents, complexities going beyond what is required for reports, and mistrust and apprehension over measures such as disciplinary actions taken against related personnel. For example, one person mentioned that no matter if you work hard in your routine duties and various activities, you are subjected to disciplinary actions for minor mistakes that cause a train to be delayed by just a few minutes. Another person stated that even the most minor mistakes are investigated in excessive detail, making it uncomfortable for the person who made the mistake. There were also opinions that indicated a misunderstanding on the part of employees. For example, one person stated that if you stop a train to check its safety, you end up getting punished for causing the train to be delayed. Upon hearing these opinions, top management became strongly aware that company policies were not being conveyed to field personnel. Additional opinions indicated considerable apprehension concerning what actions should be taken during an emergency with respect to the duties they are performing, the desire for more education and training programs, and that equipment investments allocated for safety did not match the actual circumstances at field sites.

Upon returning to the company headquarters, top management examined these valuable opinions and deployed the following types of policies. In order to remove any mistrust on the part of field personnel concerning accident and incident investigations and related disciplinary actions, company policy was changed; instead of focusing on disciplinary actions, the objective was to look for signs of the potential for serious accidents in minor incidents and accidents, and then to implement effective countermeasures by gaining a correct understanding of the contents and causes of incidents, since simply taking disciplinary actions will not solve the problem. In addition, the term "liability accidents", which had previously been used to refer to incidents caused by human error on the part of employees was abolished. To provide practical training programs for employees, comprehensive training centers were established at each branch office, and programs including simulation training were conducted that involved predicting actions to be taken in a simulated emergency by using simulated equipment such as train rolling stock, stations and signals. In addition, in order to make detailed investments in safety equipment that precisely matched the needs and actual conditions of field sites, construction funds were allocated to the chief of each branch office in the amount of a million dollars. This measure also served as an opportunity to expand the transfer of authority to branch offices that would take place in the future.

The second round of the "General Safety Inspections" was held 7 months later in July 1989 in order to check on the progress of those matters implemented in the first round, including the above policies. Field personnel were conspicuously more aggressive in their expressing of opinions in comparison with the first round. During the time that had passed since the first round of General Safety Inspections, the worst accident in the history of our company occurred in which a train stopped at a station was run into by a following train, resulting in 2 deaths and more than 100 injuries. As a result, many of the discussions that took place focused on safety policies, including expanding the introduction of systems that drastically improve safety, such as a safety system that can prevent accidents from occurring even when there has been an error by the operator, or a safety device in which protective functions cannot be removed or are not required to be removed. In addition, numerous opinions were expressed concerning train control duties, such as strengthening the execution system of those duties and the training system for controllers, and improving wage conditions in consideration of the importance of train control duties in railway operations.

Thus, the discussions held at each field site covered a broader range and were more in-depth, and all persons concerned had a deeper awareness of the importance and effectiveness of direct discussions between the front-line personnel and members of top management, from the president on down. Since it was judged that are probably many more subjects that should also be discussed, it was decided to hold "General Safety Inspections" every year.

(7) Implementation Status up to the Present

The "General Safety Inspections" have been held once or twice a year since their second series, and this year marks the 14th time they will be held.

During this time, 2,120 field agencies have been visited, and more than 15,000 persons have participated in discussions. This figure covers nearly all major field agencies and corresponds to 25% of the roughly 60,000 employees engaged in railway operations and businesses.

The following is a list of some of the themes that have been taken up in the past.

- Ensuring safety during track maintenance work
- Ensuring safety during field work involving signals and communications
- Safe coupling and uncoupling of trains
- Level crossing safety countermeasures
- Introduction of new systems and corresponding education and training
- Present state and important topics for the future relating to rolling stock maintenance
- Problems in training new crew members

(3) Results

The following results were achieved from the "General Safety Inspections" that have now been conducted for the past 9 years.

- We were able to determine weak points in safety at field sites and develop countermeasures.
- We were able to suitably develop various safety measures based on the actual conditions at field sites.
- We were able to draft and implement mid-term plans for improving safety and efficiency for each field of operations. These mid-term plans are for radical improvements in the manner in which operations are conducted, including safety measures, and are implemented by forming project teams for each field of operations, such as track maintenance, signals and rolling stock, and proceeding with the development and introduction of new technology based on the results of studies conducted at company headquarters.

- We were able to establish crew member education and training programs as well as install and improve the equipment required for those programs.
- The company headquarters was able to gain an understanding of the actual state of field operations along with the opinions of field personnel, while field personnel were able to understand the policies and way of thinking of the company headquarters, thus deepening a sense of mutual understanding and unity.

The status of the occurrence of railway operating accidents since 1987, when our company was established, is shown in Fig. 3. As can be seen from this graph, the number of accidents has decreased remarkably and the level of safety has improved. We are convinced that these "General Safety Inspections" are contributing greatly to these results.

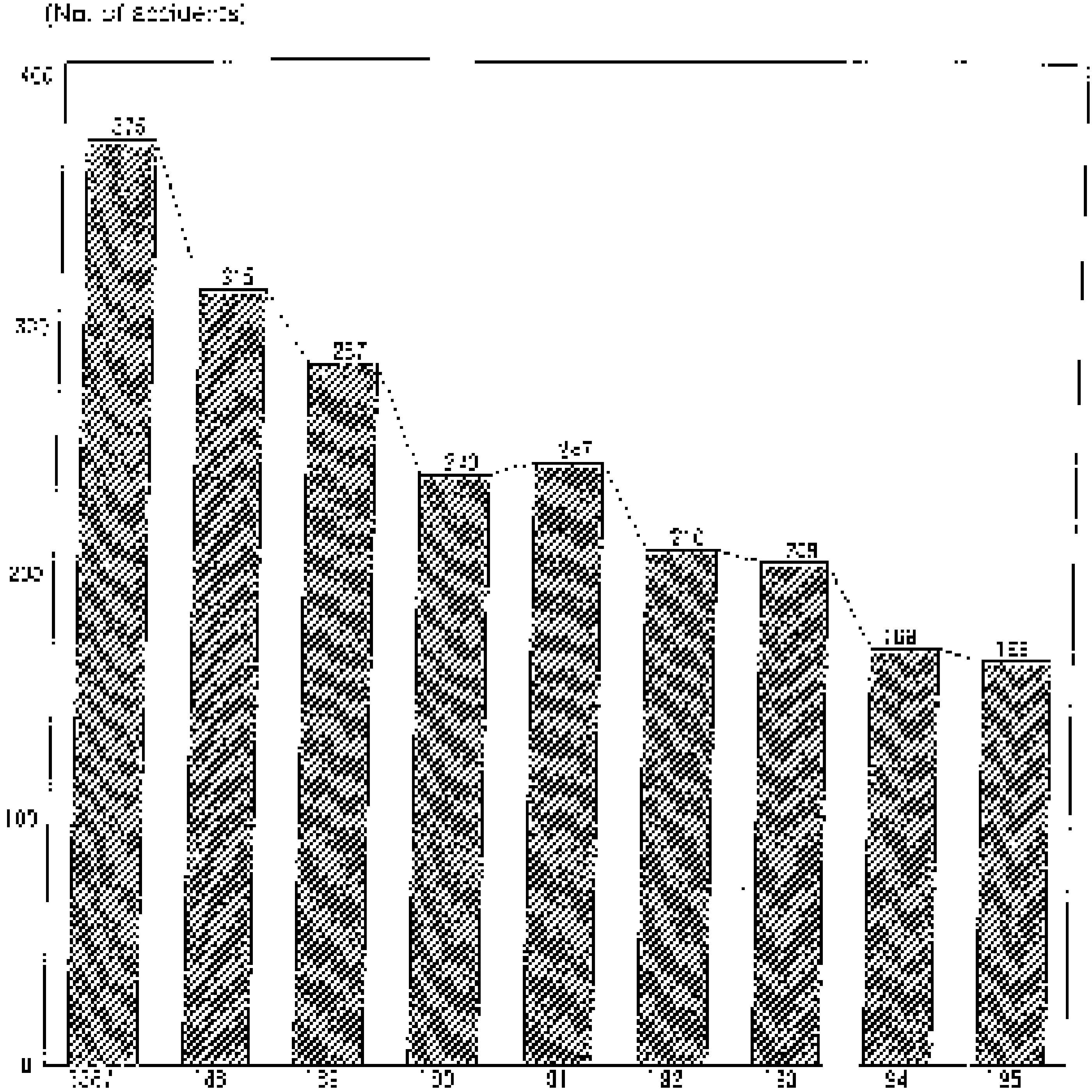

Fig. 3 Railway Operating Accidents, East Japan Railway Company

3. Future Outlook

As has been described, "General Safety Inspections" have produced numerous significant results, and play an extremely important role in terms of the implementation of safety measures by our company.

Through these "General Safety Inspections", the company headquarters was able to achieve unity throughout the company with respect to the following.

- "General Safety Inspections" offer a valuable opportunity to directly gain an understanding of the actual conditions at field sites; and,
- Problems can be resolved rapidly since studies of problems are conducted by a cross-sectional organization that goes beyond boundaries between divisions.

On the other hand, "General Safety Inspections" had the following effects at field sites:

- Awareness of various issues can be heightened through discussions with members of top management; and,
- Promotion of problem-solving at field sites results in improved morale.

Thus, we intend to continue conducting these General Safety Inspections in the future as we deal with various issues that arise.

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Hirokazu Miki

One-Man Operation and Safety: The Aspect From Union

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CURRICULUM VITAE

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INTERNATIONAL RAILWAY SAFETY CONFERENCE 1996
[illegible] 07—09 OCTOBER 1996

ONE—MAN OPERATION AND SAFETY
— THE ASPECT FROM UNION

by
Mr [illegible], [illegible]
East Japan Railway Workers' Union (JREU)

1. Union's view of one—man operation as the pursuit of efficiency

One—man operation means that a driver operates a train without a conductor's collaboration. The driver's duty is of course to operate a train safely and the conductor's is to deal with passengers. However, the conductor's collaboration is essential for keeping train operations safe. Especially, when an accident occurs he has to conduct passengers to evacuate them and protect the following train and other trains running on the adjacent tracks from a secondary accident to minimize damages.

Because of the different roles of the driver and the conductor, naturally, both of them are on a train. But as a result of the development of automobiles, management of public land transportation, such as railways and buses, faced a crisis. From the 1950's, the bus industry introduced the one—man bus system in order to improve efficiency, but the railway was behind them because railway trains are bigger and driving distance was longer compared with buses. As the number of automobiles increased dramatically in the 1970's, small local railway companies began to introduce the one—man train system to compete against automobiles.

The unions and management reformed the former JNR and set up the new JR Companies to reconstruct its bankrupt management in 1987. So, JREU did not simply refuse the introduction of one—man train that did not exist in the JNR era.

We cooperate with the management to promote efficiency that is necessary to enhance the value of the railway in the future but certain preconditions should be fulfilled. We need to be sure to maintain safety covering the whole railway system, to ensure workers' health and to work pleasantly. When examining whether one—man trains were introduced we believed that the safety was the most important issue among those conditions. If safety is not assured, a one—man train does not mean improvement of efficiency even from the view of the management.

2. Development of introduction of one-man train operation in JR East

One-man train operation was introduced initially in the Ominato line of JR East area in March 1988, the year after the new JR started.

The Ominato line is in the northernmost part of the JR East area and the passenger density is very low. The company intended to improve efficiency and we thought it was important for us to carry out measures that contribute to the management. Furthermore, we considered other elements: how to preserve the line for local passengers' convenience and for our union members' employment.

After the first introduction of one-man operation its use on other lines extended year by year.

By the end of fiscal year 1991 one-man operation extended mainly on regional local lines that were originally targeted but after fiscal 1991 it expanded to main lines.

As a result, the distance of one-man operation on main lines became longer than in local lines. It began in certain sections of low density main lines but the volume of traffic was much more than the local lines. So a certain number of one-man trains were composed of two carriages and at first the facilities that were indispensable to one-man operation were not fully provided on the main lines. Thus several problems developed.

Other various kinds of problems have arisen. For example, as one-man operation was extended and non-staffed stations increased year by year, the duties of one-man train drivers increased dramatically. Passengers' bad manners and cheating on fares became constant headaches for drivers.

The latest situation of one-man operation is as follows. By March 1998 its operation distance had reached 2,900 km and its ratio accounted for near 30% of whole JR East operation distance.

Chart 1 YEARLY EXTENSION DISTANCE (km)

FISCAL YEAR	MAIN LINES	LOCAL LINES	TOTAL
1987	4.1	58.4	62.5
1988	4.7	71.3	[illegible]
1989	20.3	44.7	[illegible]
1990	[illegible]	191.6	[illegible]
1991	21.6	574.3	595.9
1992	27.5	0.0	27.5
1993	375.6	133.2	508.8
1994	205.7	9.0	214.7
1995	214.3	94.0	308.3
TOTAL	974.1	1119.4	2093.5

Chart 2 YEARLY AGGREGATE EXTENSION DISTANCE (km)

FISCAL YEAR	MAIN LINES	LOCAL LINES	TOTAL	RATE (%)
1987	4.1	58.4	62.5	2.0
1988	8.8	[illegible]	88.0	1.9
1989	28.4	174.4	[illegible]	2.3
1990	28.4	375.0	344.4	5.2
1991	51.6	893.3	1001.2	15.6
1992	138.5	890.9	1029.2	15.4
1993	514.1	1023.5	1537.6	23.1
1994	730.7	1029.5	1760.5	26.3
1995	974.1	1119.4	2093.5	31.4

3. Regulations on one-man operation

In general we say that one-man operating means one driver operates a train without a conductor's support but it has not been defined clearly by any laws and regulations.

Historically, in 1971 the Kanto Railway, a local private railway company, introduced one-man train in 1971. At that time, it was allowed only when the Minister of Transport approved it in conformity with an exceptional clause of the Local Railway Operation rule. From 1975 the Minister's approval was not necessary because of further amendment of the rule.

The former National Railways introduced one-man trains, limited to freight trains, in 1980 just before the JNR reformation.

When the new JR started in 1987 rules concerning the Japanese National Railway and the Local Railway Operation rules were abolished and a new Railway Operating Rule was enacted instead. This rule refers to where one–man operation is allowed : considering conditions of traffic and situation of lines if the train can be operated safely without a conductor, it will be approved.

According to the law, when a driver happens to be unable to operate a train he has to be able to apply an automatic emergency brake equipped in the train and operate train signal safely. Although it is supposed to be ineffective, " administrative guidance " issued by government agencies is more effective as a business practice in Japan. Railway undertakings run their business following the guidance.

The Transport Ministry's administrative guidance regarding the Railway Operation Rule is as follows.

Business guidance : details of the Railway Operation Rule

1. Single track section

1–1 Circumstances of line

There is no place that will block passengers from evacuating from the train when an incident occurs.

1–2 Situation of train operation

Passenger density is not high, so one–man trains can be operated.

1–3 Composition of carriages

Concerning passenger trains, the number of carriages is not many, so one–man trains can be operated.

1–4 Others

a. When driving backward, a staff member should ride in the front of the train to guide safely.

b. A driver can see inside the carriage clearly from the position where he handles the door switch.

c. Staff involved in one–man operation should be educated and trained for a sufficient period.

d. The railway undertaking should educate passengers over a sufficient period.

2. Double track section

The railway undertaking should fulfil the above conditions and provide facilities to protect the train automatically from danger from adjacent tracks where there are sharp curves and visibility is restricted.

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4. Problems at real work

There are laws and rules, at least, but they are so abstract that railway undertakings have to manage how to maintain safety — it depends on managers' decision.

The laws and rules were laid down supposing all passengers were people of good will. However it is wrong in reality. Some of passengers intend to cheat on fares because of a one-man train. Even if they are good they are not calm and neat. One-man train drivers have to deal with different types of passengers. Examples are rushing passengers who try to get on the train that is about to depart, elderly people, tourists, drunkards and so on.

One-man train drivers have to deal with these passengers who are not assumed in the laws. We began to know their mental stress was accumulating and we started to feel misgiving about potential accidents.

After one-man operation started drivers' duties increased. Besides driving they have to care for passengers' safety such as watching their steps on and off the train. They also have to give information to passengers on the intercom and sell and collect tickets. We feared that drivers' original attention to driving trains might fail.

According to our union's survey, 62 % of drivers said that they had trouble with passengers over dealing with fares and so on. It is clear that these troubles made drivers upset. Especially, it might be a remarkable fact in JR East most drivers worried about cheating on fares. The company said that they wanted the drivers to make every effort to keep safe driving. Cheating on fares was below 2 %. Drivers should intend to drive safely and not have accidents because of being nervous about fare cheaters. However, in our survey, 50 % of drivers said that fare cheating affected their work.

In addition, train drivers are accustomed to drive trains accurately. Although the company tells that the safety issue has priority over accuracy, drivers are always in a dilemma between them. If he stops for too long when he is dealing with passengers he will tend to be in hurry to keep schedule accurately. As a result, he does not notice the red signal and might let the train start wrong. In fact, an accident was recorded that one of drivers failed to observe the starting signal but started.

Chart 3 Process of the accident

DRIVER'S ADDITIONAL DUTIES	STRESS FACTORS	CAUSES OF ACCIDENTS	ACCIDENTS EXPECTED
Passengers' safety	[illegible] operation	Being in a hurry	Flying start
Giving information	Fare checking	Mental stress	Passing station
Selling & collecting tickets	Uneasiness	Unskilled	..
Emergency action			Collision ?

5. Negotiations and agreement

Union and management reached agreement and signed notes three times : The first was in December 1987 just before the start of one-man operation in March 1988. We signed the second and third, when one-man operation extended rapidly, problems emerged and union members strongly demanded improvement .

Chart 4 Progress of rationalization

FISCAL YEAR	NEGOTIATIONS		TOTAL (km)	RATE(%)
1987	December	Conclusion of note	62.5	0.5
1988			62.6	1.0
1989			152.8	2.5
1990			344.4	5.2
1991			1010.5	15.2
1992	October	Conclusion of note	1029.3	15.6
1993	November	Traffic Survey	1537.5	25.1
1994			1760.2	26.5
1995	December	Conclusion of note	2092.5	31.4

One-man operation was on the agenda three times during union and management collective bargaining. This means that problems concerning one-man operation are various and difficult. Regarding facilities, they have been improved gradually but the levels have not been standardized or they need to be improved again. For example, the company put a mirror on a platform but it did not work because of deep snowfall.

The union compiled a basic [illegible]-point demand on one-man operation and talked with the management but we have not reached a conclusion. In the negotiation on working conditions it is usually very difficult that opinions between union and management can agree perfectly but we believe that the problems will be solved through serious negotiations.

Union and management reached conclusion of the third case in December 1995.

AGREEMENT OF JR EAST UNION AND MANAGEMENT ON ONE-MAN OPERATION

1. Prospect of standard on low density (rail) lines and less crowded space
   Review one-man train operation considering special circumstances of the lines, passengers and rolling stock.

2. Prospect of maximum number of rolling stock on a one-man train
   In the present circumstances not more than two.

3. Prospect of remodeling and renewal of rolling stock
   Present remodeled rolling stock cannot be replaced immediately but the company will remodel it to be more user-friendly.
   When the company orders new rolling stock for one-man operation the management will take advice from the one-man train drivers.

4. Prospect and schedule of introduction of ATC to the electronic stoppage section of line.
   In this fiscal year in the electronic stoppage section of line the company will take measures to prevent wrong departures because of driver errors, for example, install some preventive equipment.

5. Prospect and schedule of fully equipping of train radio.
   When new one-man operation starts train radio will be fully equipped but at the moment the company should provide cellular phones complementarily and also discuss development of new communication technology.

6. Prospect of keeping safety in ultra-long tunnel
   If the train goes through an ultra-long tunnel more than 2,000 m the controller should know the time of going in and out. If it takes much time to go through the tunnel the company should equip devices to communicate to the controller. The company will install signal

cables in the tunnels from 500 m to 2,000 m long

7. Prospect of installing a partition board between a driver and passengers' car.
The company will immediately install a partition board made of acrylic resin to protect the driver.

8. Prospect of preventive measures against passengers' dishonest acts.
The company will investigate the fact of passengers' dishonest acts and take preventive measures against them, for example, installing a ticket reader which passengers through between trains or examining ticket in the train.

9. Prospect of conductor's duties during holiday season
Conductors will not be on the trains during the holiday time.

10. Prospect of one-man operation in the section of double-track line
The company should install radio devices for train protection and train radio system and also equip the train approaching limit warning devices in the tracks that run next to another company's line.

6. Conclusion

Originally, managers decide managerial problems. However, one-man operation concerns not only improving efficiency as one of the managerial problems, but also the matter of railway safety. This case is related to drivers' working circumstances. So, we insist that we should create circumstances so that the drivers can work without anxiety.

Safety is the basic concern for railway undertakings. As the union and management of JR East understand that the safety issue should be tackled in common, we have discussed one-man operation and other safety problems seriously.

A fatal accident that is caused by one-man operation involving passengers has not been reported but a certain number of incidents have occurred. We are afraid that they might lead to the big accident. The Japanese laws and guidance from supervisory government offices are so vague that we cannot cope with incidents causing everyday.

Now you can see one-man train drivers feel anxious about passengers' dishonest acts while they *[illegible] speciality. We would like to propose the company should face up to the reality and take advice from workers who have real wisdom.*

The union's tasks are of course to aim at securing, [illegible] and [illegible], working conditions. However, we have seriously taking account of the managerial matters, such as the revenue. I am afraid foreign people might not be able to understand that. We regard keeping safety as our priority and will every effort to maintain the railway that is one of the main transport means in Japan in the 21st century.

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Paper 9622

Makoto Mizukami

Union's Tackling of One-Man Train Operations

CURRICULUM VITAE

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SOMERSET WEST, SOUTH AFRICA 7 – 9 OCTOBER 1996

UNION'S TACKLING : IMPROVEMENT OF ONE–MAN TRAIN OPERATION

By
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Vice chairman of Transportation and Rolling
stock Section of JREU

1. INTRODUCTION

One–man operation of passenger trains, which was introduced after the new JR started, has been advanced to 4,000 km over 51 lines. This distance is about 59 % of all lines of JR East.

In one–man operation, a driver has to operate a train alone. At the same time he has to do other work that conductor and station staff used to do. The drivers concentrated on their driving work but they have not focused on only their original duties.

East Japan Railway Workers' Union (JREU) accepted one–man operation in order to preserve local railway networks and maintain our workplaces for our members. However, each regional office of JR East introduced this measure without considering standards. As a result, facilities and circumstances on each line differed from the others. So, problems including safety issues arose.

As we heard many complaints and much anxiety from our union members, we, the Transport and Rolling stock Section (TRS) of JREU, began to tackle the problems of one–man operation seriously.

At first, a principal point of our project was to heighten the safety of one–man operation and to establish the concept of " ideal circumstances of one–man train operation " from the union's standpoint.

Now, I will let you know various problems that we acquired through the project. On this occasion, I will discuss mainly working circumstances of drivers and will omit the rolling stock problems.

2. START OF " ONE–MAN PROJECT TEAM "

TRS had a meeting with representatives of local organizations and set up a " One–man Project Team ". At first, we made clear the points, differences and problems of each workplace and line, then we decided to send out a questionnaire to learn about our members' feelings on one–man operation.

The items of questionnaire were 18, filled in by either a numbers choice or writing notes. The aims are, at first, to examine of maintaining safety and working circumstances in one-man operation workplaces, and secondly, to establish the real circumstances of operation from operation.

We sent out the questionnaires to our members whose work was involved in one-man operation. The number of questionnaires sent was 1,307 and returned 1,253. The rate of collection was 96 %. It was nearly 100 % returned except for people who were taking sick leave or training courses. The returned rate indicates to us that our members were very interested in this subject.
Here I will tell you some results from the questionnaire concerning safety.

2-1 What additional work burdens you ?

We asked what additional work burdens you during one-man operation besides the driver's original job. Dealing with fares comes first, 40 %, because the driver has to do work that used to be done by the conductor and station staff at the time he is on duty. What is more, he had not dealt with fares before the start of one-man operation.

Giving information to passengers comes second at about 30 %. This work is not included in driver's original jobs. As while he is driving he gives information on the intercom and answers passengers' inquiries he cannot pay attention to signals and tracks well. In fact, one of drivers started the train without confirming the signal. He spent time on caring for passengers. This case was regarded as an accident.

The top two of the answers account for 70 %. Breakdowns of the ticketing machine and protecting passengers from injury accidents follow them. Others are dealing with drunkards, handling doors and watching passengers' safety.

Chart 1 What additional work burdens you ?

Kind of work	Rate (%)
1. Dealing with fares	40.0
2. Giving information to passengers	29.8
3. Breakdown of ticketing machine	5.7
4. Dealing with equipment installed in the train	3.0
5. Train cleaning	0.5
6. Others	15.2
7. Do not feel any burden	2.0

2−2 Why does your attention to the signals deteriorate ?

We asked if your attention to the signals had deteriorated. 60 % of drivers said " Yes ". The reasons are delay of trains, giving information to passengers and protecting passengers from injury accidents. The causes include most of the additional work.

Chart 2 Reasons why your attention to the signals deteriorated ?

Reasons	Rate (%)
1. Delay of trains	57.4
2. Giving information to passengers	25.0
3. Dealing with fares	14.2
4. Protecting passengers from injury accidents	16.5
5. Others	3.7

Next, we asked if you had got into trouble with passengers. 65 % of drivers said " Yes ". The reasons are dealing with fares, travel guidance and drunken people and they account for 85 %. Troubles with passengers make a drivers mental situation unstable. What is worse, if they are involved in violence they will certainly affect train operation. Especially, cheating fares is serious and the biggest headache for drivers.

We asked if you mind passengers' dishonest acts. 85 % of drivers said " Yes " but in one region 95 % of drivers mind it. Despite the fact that one−man operation is used mostly on less crowded single track lines (some is on double−track lines), drivers intend to drive trains punctually and safely. Passengers' dishonest acts reduce the safety standard and workers' morale.

If station staffs work in every station, few passengers cheat on fares. However the more non−staffed stations are increasing under the name of efficiency, the more people try to cheat on fares.

3. SAFE WORKING CIRCUMSTANCES FOR ONE−MAN OPERATION

When you operate one−man operation you should provide equipment in the train and ground facilities. Furthermore, working circumstances, such as driving time and distance, passengers density and composition of rolling stock, are another big problem to discuss.

3−1 Limit of driving time and distance

The limit of the continuous driving time, according to the labour agreement between JR East company and union, is 2 hours and 30 minutes on the heavy traffic lines and from 3 hours and 30 minutes to 4 hours in general. We had the following results: " 60 to 90 minutes ", 47.[illegible] came first, " 30 to 60 minutes ", 23 %, second, and " 90 to 120 minutes " 14 %, third.

Next, I will move on to the limit of one continuous driving distance. We have not decided on this in our agreement. However, our members answered the following: " 50 km to 100 km ", 50 % came first, " less than 50 km ", 35 % second, and " 100 km to 150 km ", 6.5 %, third.

Actually, there are differences in driving distance, from the shortest, 4.2 km, to 141 km, the longest. The average is about 100 km. The limit replied by drivers was very moderate.

Chart 3 Limit of one continuous driving time

Limit	Rate (%)
1, less than 30 minutes	6.[illegible]
2, 30 to 60 minutes	23.[illegible]
3, 60 to 90 minutes	4[illegible].[illegible]
4, 90 to 120 minutes	14.0
5, more than 120 minutes	[illegible].5

Chart 4 Limit of one continuous driving distance

Limit	Rate (%)
1, less than 50 km	35.2
2, 50 to 100 km	50.[illegible]
3, 100 to 150 km	6.5
4, more than 150 km	[illegible].9

3-3 Rate of passengers density and composition of rolling stock

A one-man train on JR East is composed of one or two carriages today. Some of the private railway companies, however, operate three or four carriages in one-man trains if stations are staffed. There are many un-staffed stations in the JR East area. So, 48.[illegible] % of our members answered that the limit of carriage numbers should be " two " and 4[illegible].[illegible] % said " one ". Totally, 9[illegible].5 % said " not more than two ". Only 2.[illegible] % said " Three ".

Regarding the permissible ratio of passengers density, 5[illegible].[illegible] % said " 50 % to 100 % ", 23.[illegible] % said " less than 50 % ".

As passengers enter by the rear door and leave one from front, the flow of passengers must be [illegible] as the answers are natural.

One-man train drivers are responsible for driving trains safely, dealing with fares, keeping passengers safe and handling [illegible] public. They have to do several kinds of work.

Chart 5 Limit on the number of rolling stock

Limit	Rate (%)
1. One rolling stock unit	45.9
2. Two rolling stock units	48.3
3. Three rolling stock units	5.[illegible]

Chart 6 Permissible ratio of passengers' density

Maximum	Rate (%)
1. less than 50 %	28.[illegible]
2. 50 to 100 %	58.[illegible]
3. 100 to 150 %	3.2
4. more than 150 %	6.8

4. Our proposal

As a result of the questionnaire, our project team concluded drivers needed the standard of one-man operation to protect themselves. We made a standard, Transport and Rolling stock Section (TRS) proposal " Prospect of one-man train operation ". We presented it in the conference called " Policy Forum ". It is sponsored by JRPU and held every year. The following are six main points of the proposal.

BASIC CONDITIONS OF ONE- MAN OPERATION

1. One-man operation should be limited to single-track lines.
2. One-man operation should be for only one unit of rolling stock.
3. One continuous driving time should be within 90 minutes.
4. One continuous driving distance should be within 100 km.
5. Passenger boarding density should be about 50 % so that the driver can see all passengers in the carriage.
6. Operation hour should be limited from 5:00 to 15:00.

One of the project team members presented the facts and problems of one-man operation in the conference. The proposal " Prospect of one-man train operation " was approved by most participants. After the discussion the conference decided not to accept one-man operation unless the company would improve these conditions.

JRCU proposed a list of our demands regarding the survey [illegible] points to overcome the problems. I will leave out the details. We proposed :

- Clarification of one-man train operation — 6 items
- Demands about one-man train operation
  1) Maintaining safety regarding employees and passengers — 14 items
  2) Making conditions of one-man train [illegible] — 5 items
  3) [illegible] models of one-man train drivers — 6 items
  4) Promoting local lines — 1 item

At the beginning, the company reacted negatively because regional branches were responsible for measures for one-man operation. However, we discussed the safety data gathered from our union members with the managers carefully. After the series of negotiations union and management agreed to improve facilities related to safety.

5. CONCLUSION

The company introduced one-man operation as one of the management measures. It pursued improving efficiency. However, our union members tried to go along with it. Train drivers strived to perform their duties. They collect money, keep passengers safe and drive trains accurately. Naturally, investment in less busy local lines will be limited. We should invest effectively.

We always believe that the company should invest in " safety ". The management should hear voices from employees [illegible]. We feel that significant meaning in our project and the consequence of the discussion with the company. They will definitely contribute to safety of one-man operation.

We will continue to work on this subject. We will review the effectiveness of safety investment agreed between union and management. We are insisting on safer and more user-friendly one-man train operation.

1996 CAPE TOWN

1 October – 4 October 1996
The Lord Charles Hotel, Cape Town, South Africa

Paper 9623

Adriaan Izak Dreyer

A holistic, integrated Safety/Risk and Environmental Management system in support of a predictable service: Bridging the Gap from Present to Optimal Excellence

<u>CURRICULUM VITAE</u>

Adriaan Izak Dreyer

At Dreyer matriculated at the Sentraal High School in Bloemfontein in 1958.

He attained the degree B.Sc. Eng. (Mech.) at the University of Pretoria at the end of 1962 and went on to complete his MBA at the end of 1966

In 1989 he completed the Senior Management Programme (cum laude) at the University of Stellenbosch and was awarded the Director of the Management School's award for Top Student in 1989.

During 1991 and 1992 he completed an Advanced Programme in Risk Management at the University of South Africa and received the reward as Top Student in the programme for 1992.

He started his career with the then South African Railways and Harbours as an Assistant Engineer (Mechanical) in 1963, went on through the ranks until he became a Mechanical Engineer (New Works) until the end of 1980.

In 1985 he was appointed as Director (Technical) in the General Manager's Office of the then South African Transport Services where he was, amongst others, designated as Chief Inspector for SA Transport Services in terms of Section 40 of the old Machinery and Occupational Safety Act, 1983 (Act 6 of 1983).

He grew with Occupational Safety and Risk Management in Transnet Limited and currently holds the position of Group Risk Manager.

MR A.L. DREYER : GROUP RISK MANAGER, TRANSNET LIMITED

A HOLISTIC, INTEGRATED SAFETY/RISK AND ENVIRONMENTAL MANAGEMENT SYSTEM IN SUPPORT OF A PREDICTABLE SERVICE : BRIDGING THE GAP FROM THE PRESENT TO OPTIMAL EXCELLENCE

RAIL SERVICES - AN IMPORTANT ROLE PLAYER IN A MACRO ECONOMIC STRATEGY

In the Southern African context, the macro economic strategy which sets out goals for the South African economy, was announced in June 1996 by the South African Government. This strategy sets out targets such as attaining a growth rate of 6% per annum and creating 400 000 jobs per annum by the year 2000, while concentrating capacity building on meeting the demands of international competitiveness.

The plan also promotes interrelated developments such as accelerated growth in non-gold exports, an improvement in the intensity of investment and output growth and an increase in infrastructural development and service delivery.

The plan leans toward supply-side economic measures designed to lower unit cost and expedite progress up the value chain.

Transnet, and in particular Spoornet, being a major role player in the macro economic context in South Africa, can make a significant contribution to the success of the above-mentioned plans through, amongst others, its predictable service strategies.

SAFETY/RISK AND ENVIRONMENTAL MANAGEMENT TO ENHANCE A PREDICTABLE SERVICE

An integrated Safety/Risk/Environmental Management system/process approach can serve as a critical tool for the promotion of a predictable service in Transnet. (See figures 1 and 2.)

A predictable service, as the concept implies, depends upon the timeous execution/completion of certain logistic activities. The end result being the on-time delivery to destination of goods in transit to the satisfaction of the customer.

To achieve the above mentioned objectives signifies that any possible/probable delay or loss producing event should pro-actively be identified, evaluated and eliminated/controlled.

Risk, when it materialises, manifests itself in loss to people, property, process and the environment. In the logistics/transport chain the aforementioned losses invariably cause delays and counteracts the objectives of a predictable service.

The effect of the delay/impairment will depend upon the seriousness/severity of the delay/loss as well as the frequency/probability of such delays/losses taking place.

The success of a predictable service, therefore, depends to a large degree on the management of risk/loss associated with the logistics chain.

THE HOLISTIC, INTEGRATED SYSTEMS/PROCESS METHODOLOGY

To achieve success with the management of risk/loss it is suggested that a holistic, integrated system/process philosophy be adopted. (See Figures 3 and 4.)

This approach calls for the systematic but focused application of the primary risk control disciplines within a safety/risk and environmental management system in the risk/loss sensitive areas of the systems/processes involved.

The safety/risk management system must be integrated into the line management function but line management is to be facilitated/supported/monitored by safety/risk management staff.

RISK ASSESSMENT: A MAJOR FOCUS AREA

Risk assessment lies at the heart of this proposed angle of approach. (See Figure 5.)

It is maintained that risk assessment, based upon the principle of system/process analysis, can make a significant if not vital contribution to the success of the predictable service strategy.

System/process risk analysis/assessment is to be viewed against the background of describing a business in terms of an integrated system/process, with sub-systems/processes, supported by various types of infrastructure and design. (See Figure 6.)

The synergism between Safety/Risk Management, Environmental Management, Quality Management and productivity is also borne out within the interactive systems context and is to be applied as such within the concept of risk assessment and control. (See Figure 7.)

MAIN CATEGORIES OF RISK

Although the initial focus might be on assessing operating or pure risks in relation to ensuring on-time logistics associated with a predictable service, the risks such as intermediate and business/speculative risks can and should, as necessary, be considered. (See Figure 8.) Apart from necessity, the underlying reason for this being the integrative nature of the various categories of risks. Systems/processes operate/function within an environment. A holistic, integrative approach, therefore, requires essentially that the impact of the systems/processes on the environment also be considered when executing a system/process risk analysis/assessment.

RISK ASSESSMENT INCORPORATED IN THE SAFETY/RISK AND ENVIRONMENTAL MANAGEMENT SYSTEM

The risk assessment process should in essence constitute the nucleus of a safety/risk and environmental management system within a policy and organisational structure to which all levels of management and other staff are committed. (See Figure 9.)

The system/process method of risk analysis/assessment can and should be done ideally within the context of a holistic, integrative but focused approach. This implies that hazards (pure) risks, environmental aspects/risks as well as business risks are identified, evaluated and that control and financing measures are mandated in a synergistic and co-ordinated mode. (See Figures 10, 11, 12, and 13.)

LEVELS OF ASSESSMENT

Three levels of risk assessment are foreseen, viz. macro, macro/micro and micro. (See Figure 14.)

The macro level is applied to identify and prioritise the main systems/processes constituting the total/composite system/process to be evaluated.

From experience it can be stated that the macro/micro level of assessment produces the most productive results. (See Figure 15.)

In this phase of analysis risk/loss sensitive areas/aspects are identified within the process elements being analysed. Interfaces, accumulations/concentrations and changes are identified as initial main areas of potential risk/loss.

The severity/probability of potential risk/loss, as well as immediate and associated basic causes of potential risk/loss, are evaluated and prioritised.

Current control measures/standards and associated management systems that are already in place to eliminate/control potential risk/loss (addressing basic causes), must be identified and any shortcomings thereof determined.

Where deficient, additional measures/standards and associated management systems are developed and implemented within the risk sensitive system/process elements with potential risk/loss, in order to eliminate/control the potential basic causes, as identified.

Micro-detailed or discipline specific analysis might be required within certain system/process elements, in order to pinpoint specific detailed basic causes of potential risk/loss for detailed control purposes.

A HOLISTIC, INTEGRATIVE SAFETY/RISK AND ENVIRONMENTAL MANAGEMENT SYSTEM, TO ENHANCE A PREDICATABLE SERVICE : BRIDGING THE GAP

The risk assessment/review process and associated management systems constitute essential components of what is considered to be the key building blocks/key result areas in a holistic, integrated but focused method of bridging the gap from the present to the optimal excellence position in protecting people, property and the environment (and the mission statement and business strategy of a company such as Transnet, and which would also enhance the predictability of service in the railway industry. (See Figure 16.)

Experience has proven that certain building blocks or key result areas are required to protect people, property and the environment through the prevention/elimination/reduction of risks/loss and the minimising of those losses that still occur.

The different hierarchical levels within an organisation e.g. Group Office, Business Units and Operational Units, are all role players with varying levels of involvement in relation to the different key result areas.

The following building blocks are considered essential for bridging the gap between the present to the optimal excellence position in controlling risk/loss and thereby enhancing a predictable service within an organisation.

- Legislation in regard to health, safety, environment, etc.
- Knowledge of safety/risk/environmental/quality management principles
- Safety/risk/environmental/quality management research and development and continuous improvement
- Incident reporting and causal analysis/follow-up action and review

- Risk/environmental assessments/reviews; macro, macro/micro [illegible] as well as [illegible] specific assessments/reviews
- Safety/risk/environmental/quality management techniques/[illegible]/standards/management systems
- Macro and micro risk/environmental quality management monitoring/auditing
- Internal risk/loss financing
- External risk/loss financing
- Crisis management
- Optimisation of the cost of risk/loss
- Safety/risk/environmental management strategy/policy/strategic objectives as well as business unit and operational objectives
- Supporting organisational structures and resources
- Co-ordinated application of primary risk/environmental/quality management disciplines
- Leadership commitment, communication and culture
- Training in risk/environmental management
    - Safety/risk/environmental management staff
    - Line management staff
    - Operating staff
- Management information systems. Computer assisted safety/risk/environmental/quality management systems
- National/international benchmarking

It is believed that a holistic integrated safety/risk and environmental management system, comprising all the above building blocks, should constitute an important if not critical element in rendering a predictable service in the rail transport industry a success, and bridging the gap from the present to the optimal excellence future position.

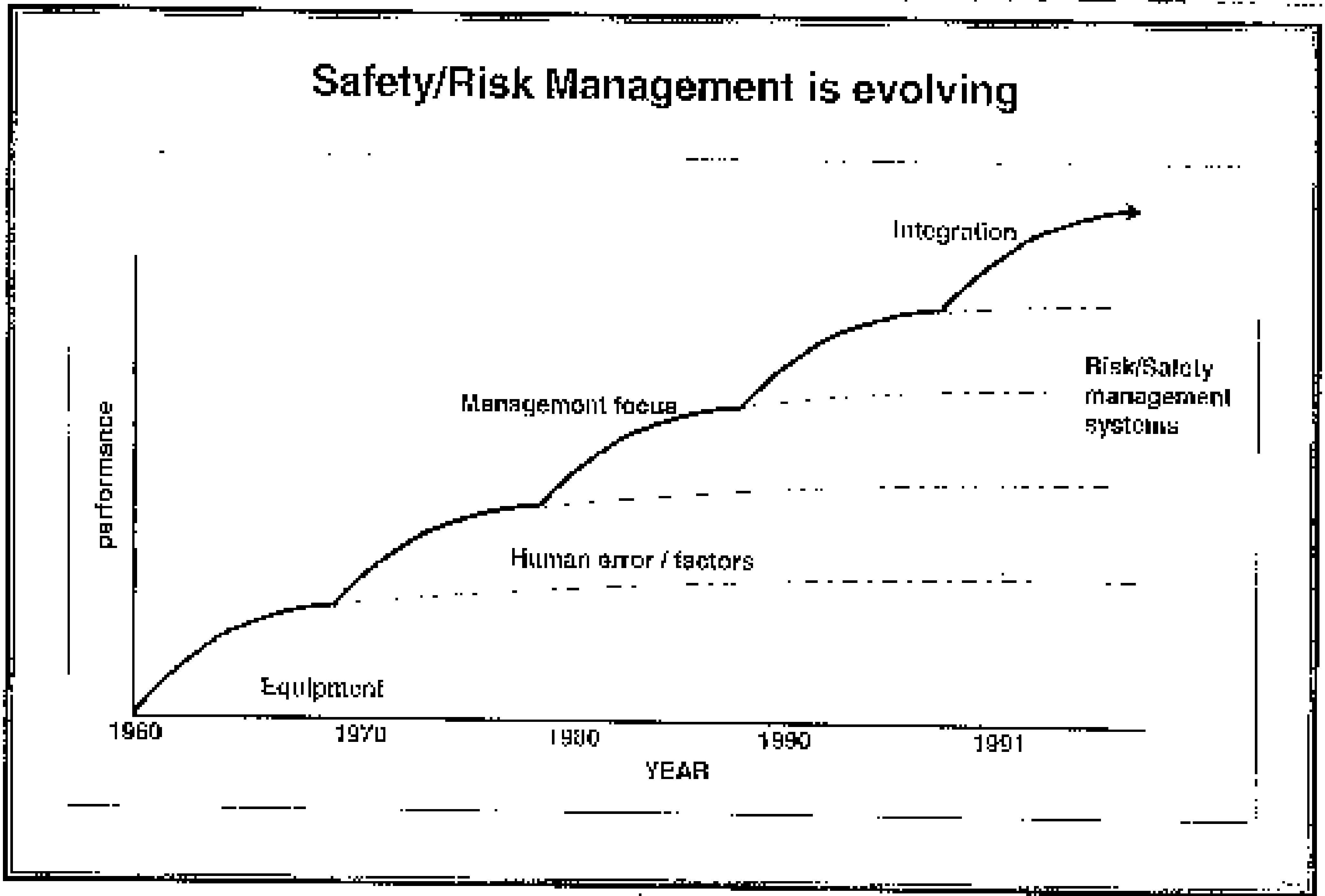

Safety/Risk Management is evolving
Integration
Risk/Safety management systems
Management focus
Human error / factors
Equipment
performance
1960
1970
1980
1990
1991
YEAR

Figure 1

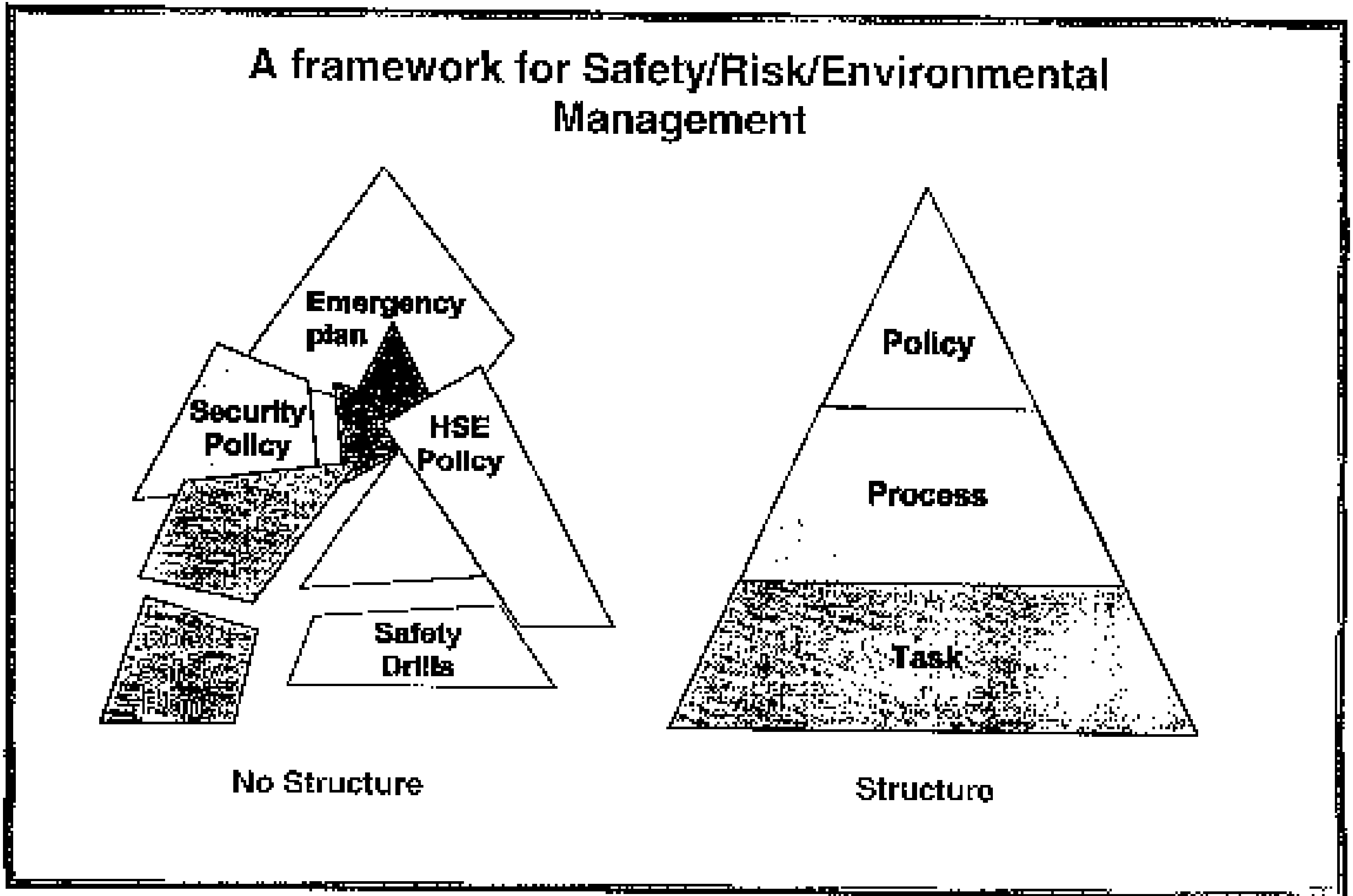

A framework for Safety/Risk/Environmental Management
Emergency plan
Security Policy
HSE Policy
Safety Drills
No Structure
Policy
Process
Task
Structure

Figure 1

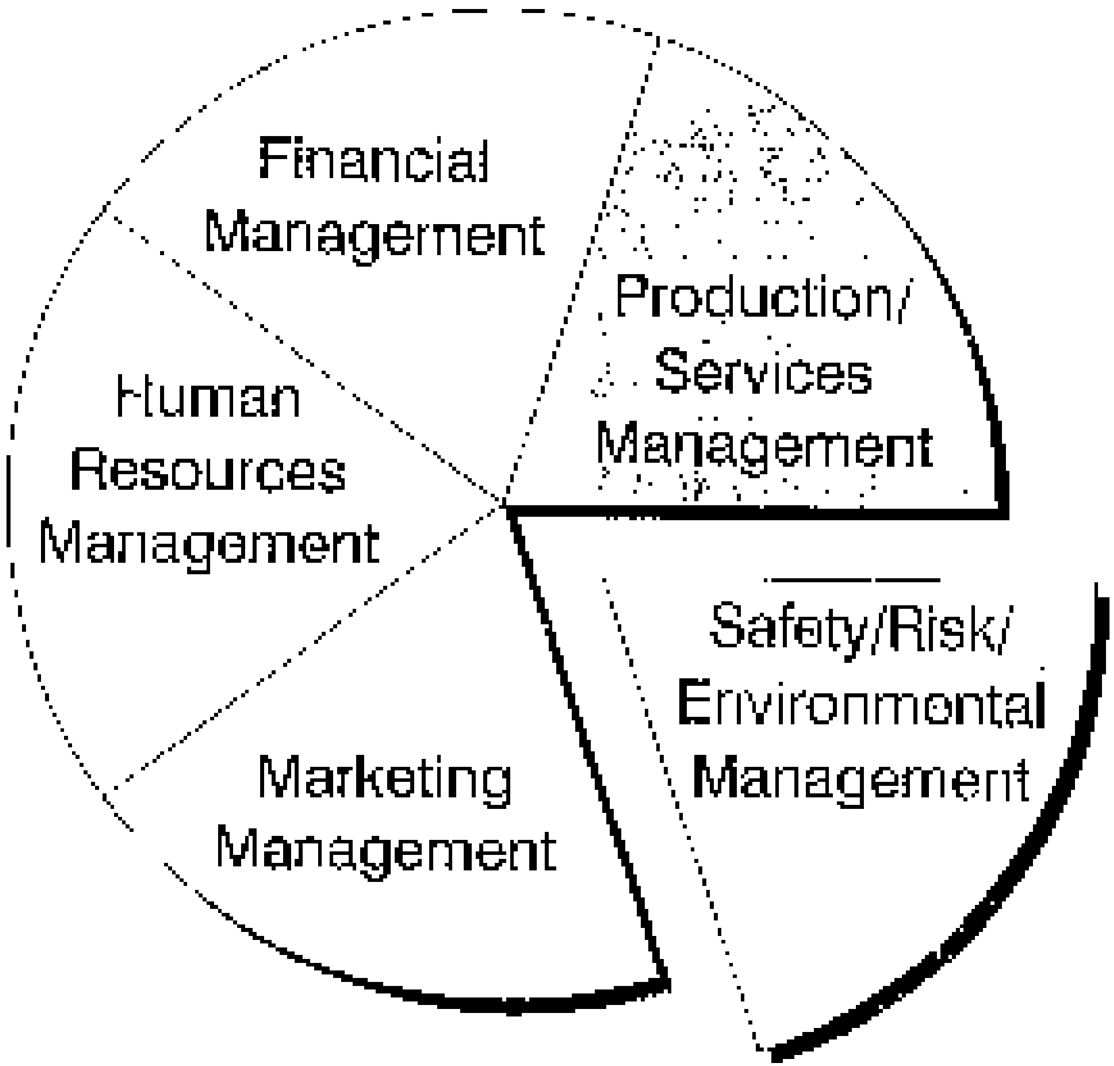
Safety/Risk Management

A Holistic, Integrated but Focussed Approach

Figure 1

The Management Wheel

Functional management processes within an organisation



Safety/Risk/Environmental Management

Figure 4

Stages of evaluation of Risk Management

Stage	Approach to Managing Risk	Reliance on Formal Systems
Fire-Fighter	Organisations that react only after an accident or new legislation is enacted.	Very few formal systems
Compliance Driven	Content with just meeting legislative requirements Implement industry standards and procedures	Formal systems of varying complexity
Risk Management	Identifies and assesses hazards/risks inherent in operation Implement management systems suitable for those hazards/risks	Aspects of risk management integrated into standard operation
Continuous Improvement	Actively seeks alternative approaches or technologies to reduce hazards/risks	Most aspects of risk management integrated into standard operation

Figure 5

An Integrated Systems Approach to Safety/Risk/Loss Management, Environmental Management, Quality Management, Productivity and the Financing of Risks/Losses.

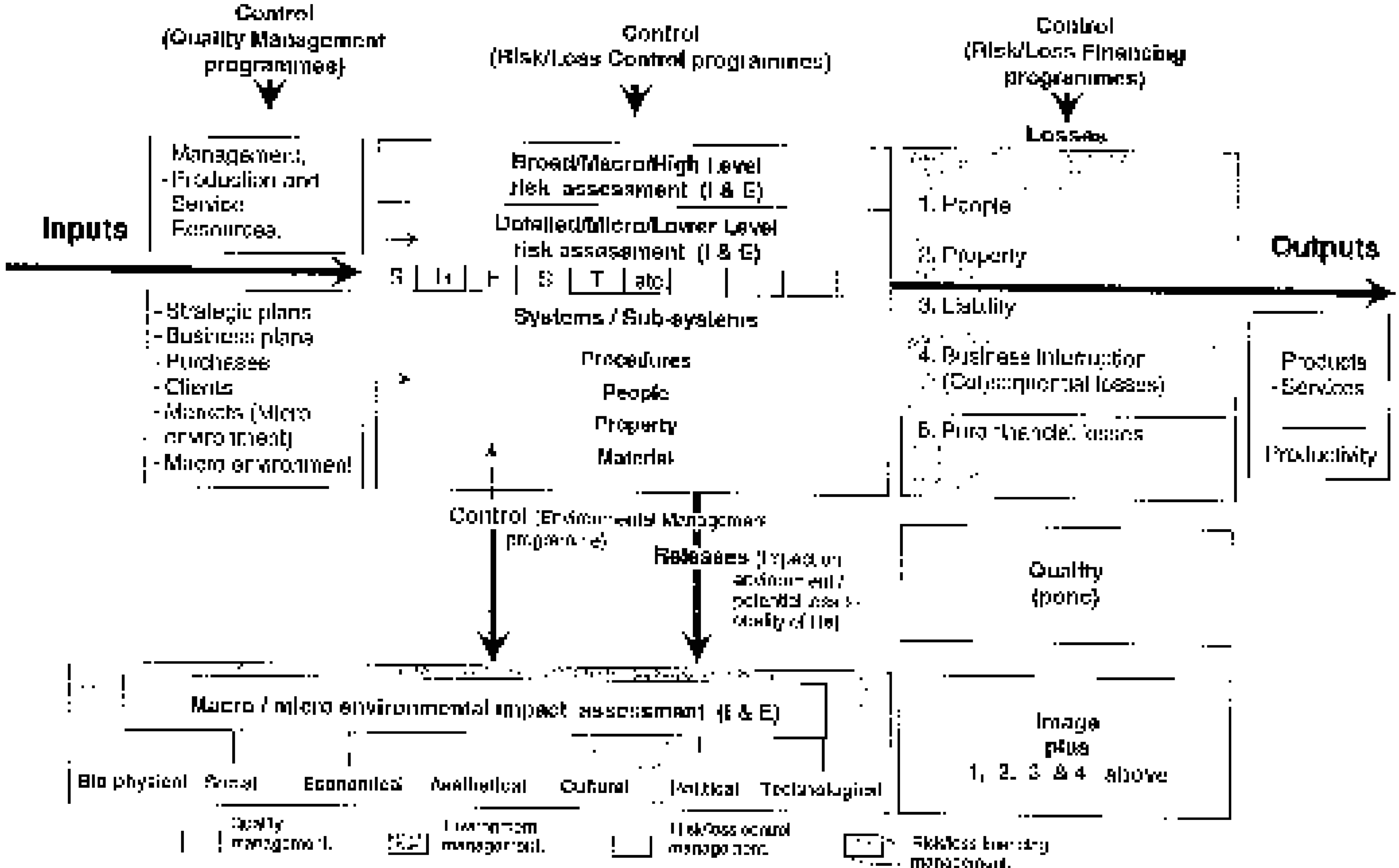


Figure 6

Synergism between Risk Management, Environmental Management, Quality Management & Productivity

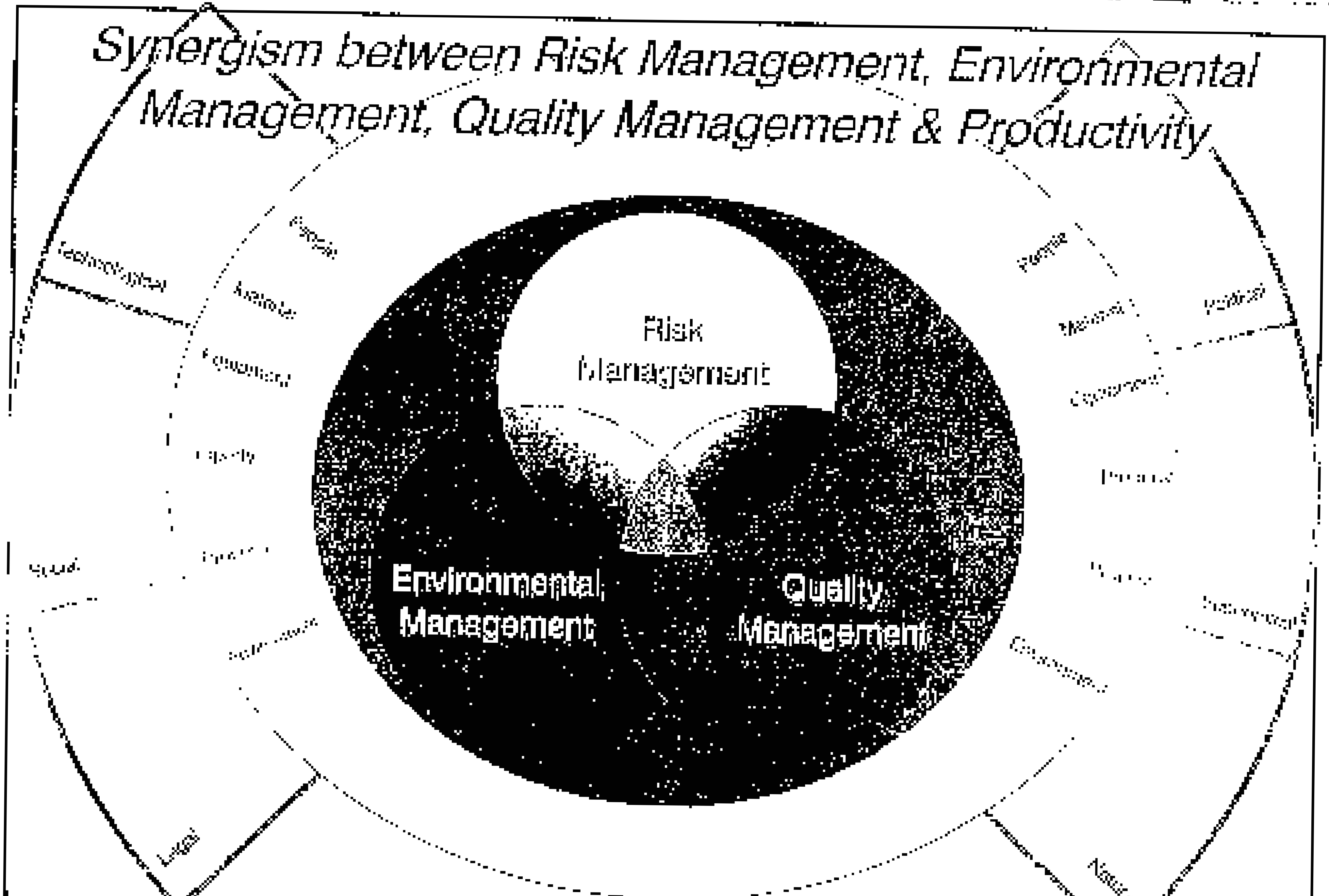


Figure 7

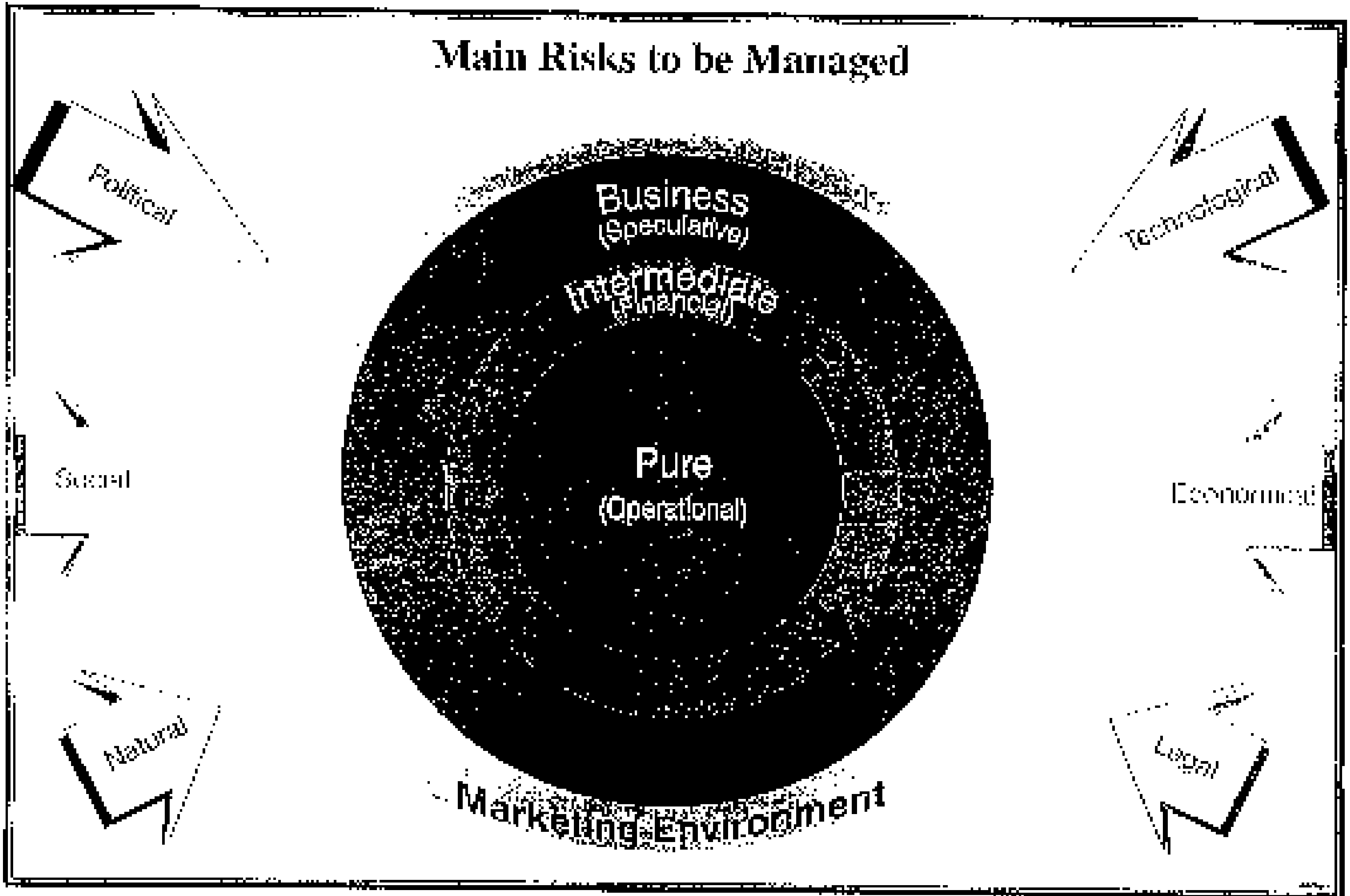

Main Risks to be Managed
Political
Technological
Social
Economical
Natural
Legal
Business
(Speculative)
Intermediate
(Financial)
Pure
(Operational)
Marketing Environment

Figure 8

Model Safety/Risk/Environmental Management System

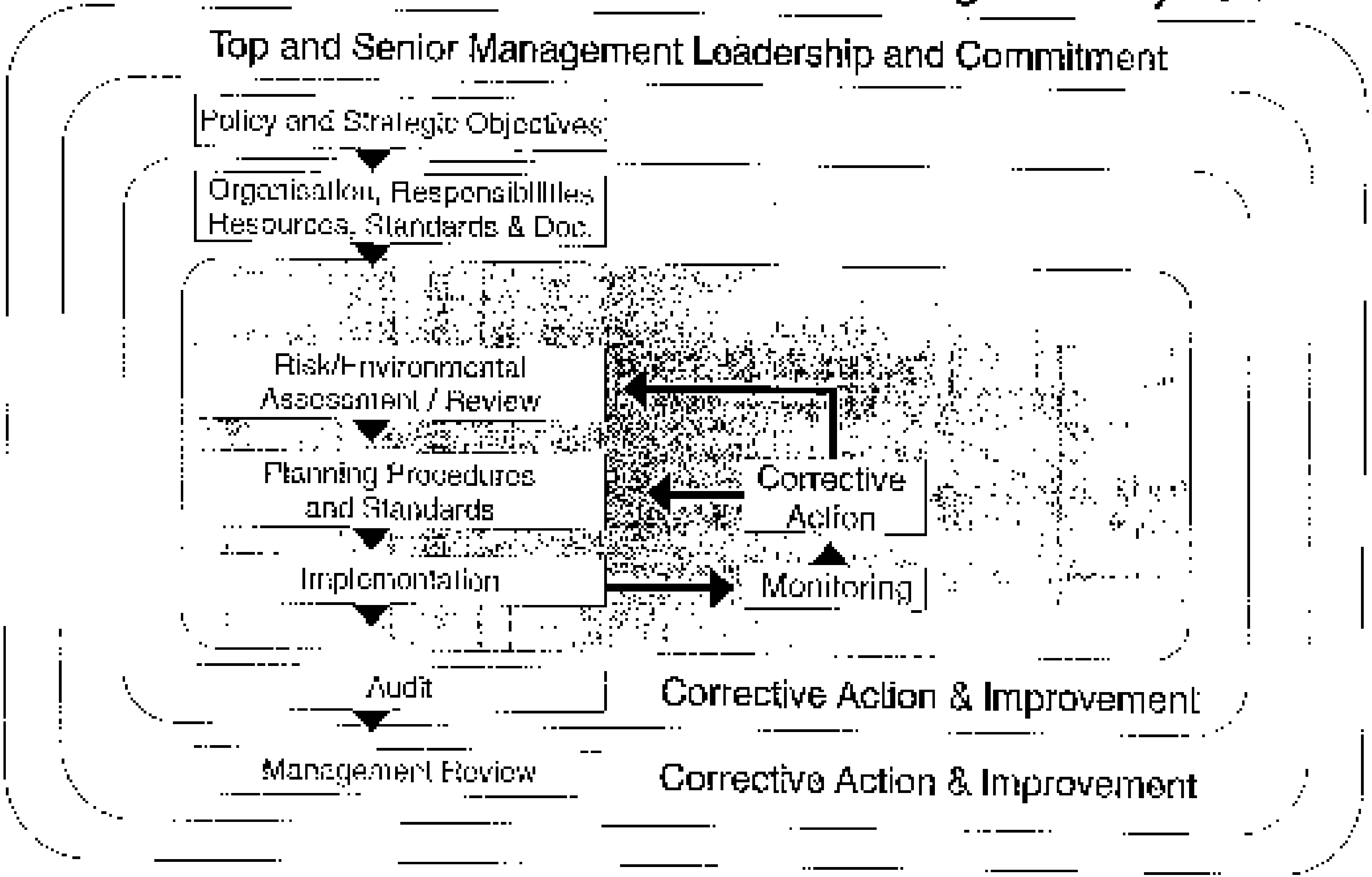


Figure 9

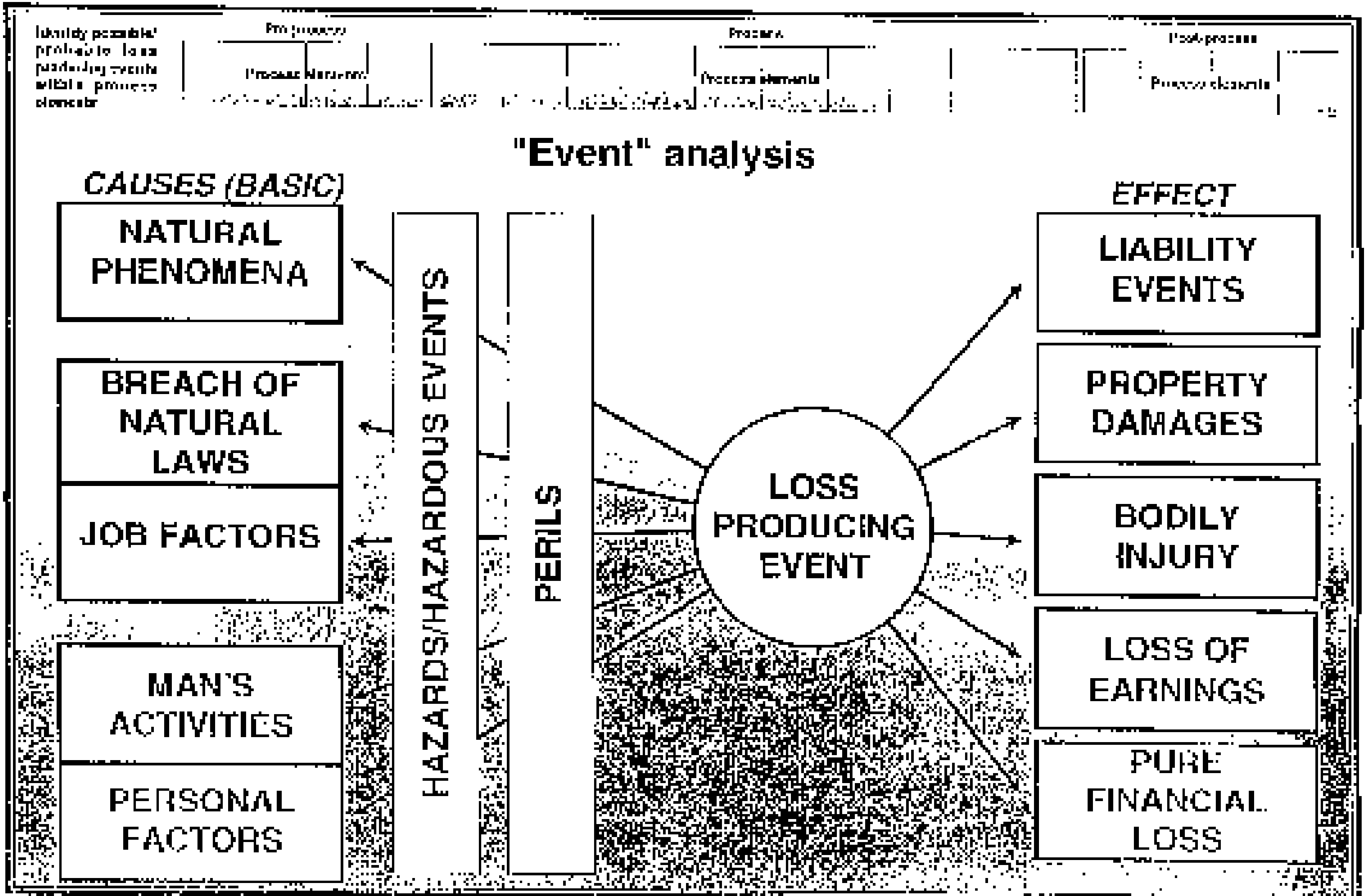

Identify possible/probable loss producing events within process elements
Pre-process
Process elements
Process
Process elements
Post-process
Process elements
"Event" analysis
CAUSES (BASIC)
NATURAL PHENOMENA
BREACH OF NATURAL LAWS
JOB FACTORS
MAN'S ACTIVITIES
PERSONAL FACTORS
HAZARDS/HAZARDOUS EVENTS
PERILS
LOSS PRODUCING EVENT
EFFECT
LIABILITY EVENTS
PROPERTY DAMAGES
BODILY INJURY
LOSS OF EARNINGS
PURE FINANCIAL LOSS

Figure 10

Safety / Risk / Environmental Management Process

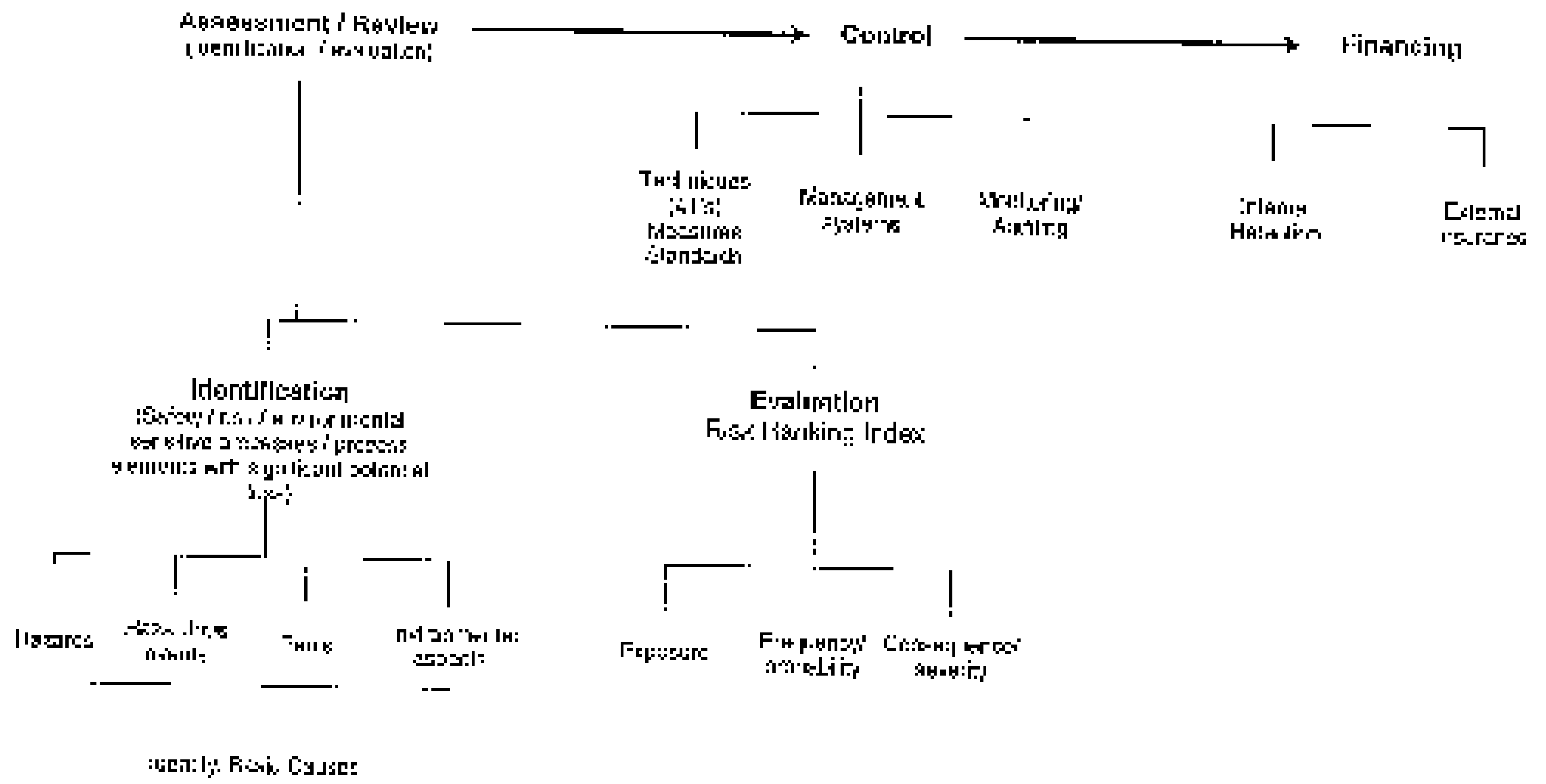
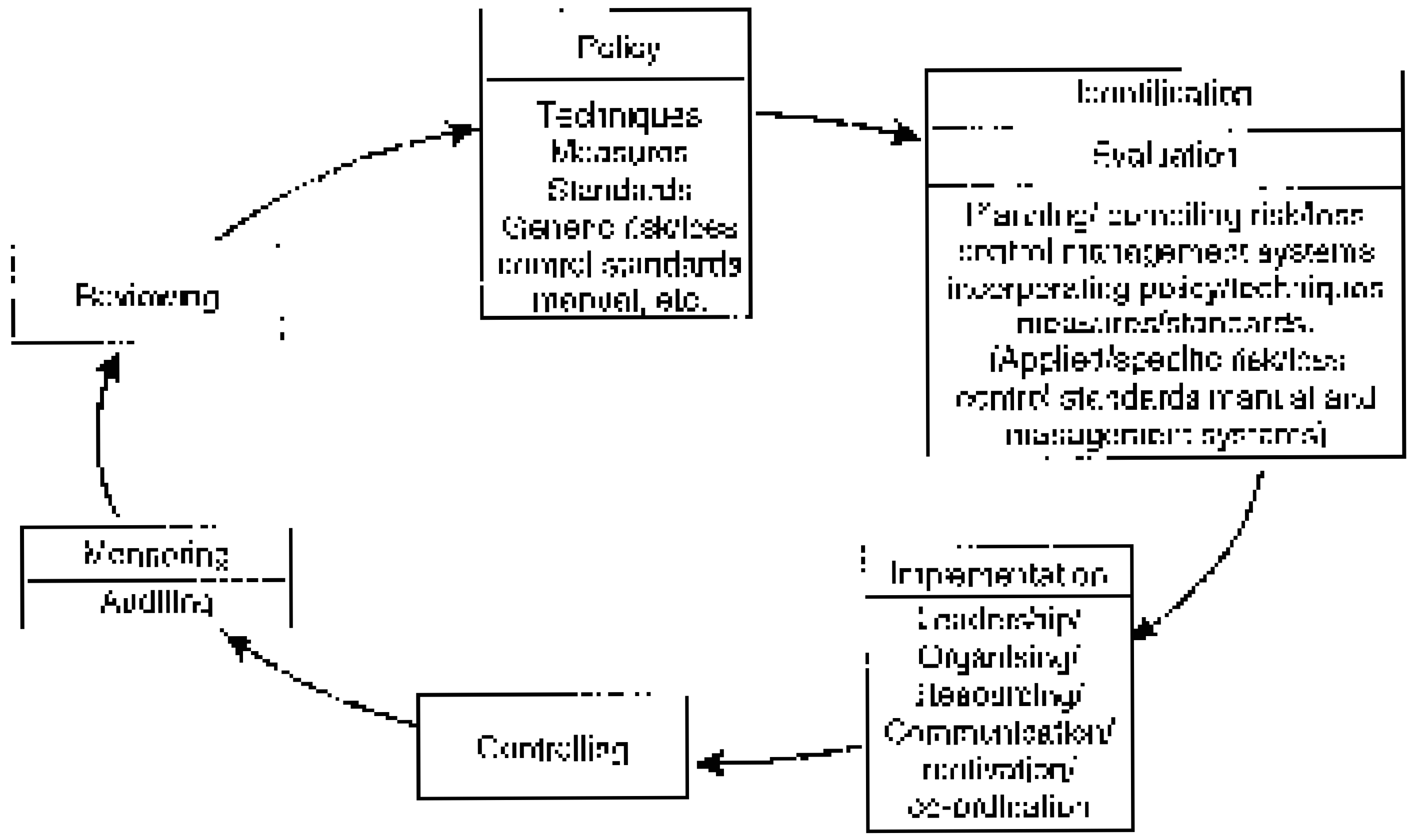


Figure 11

Safety/Risk/Environmental Management Systems



A six step approach can be used to manage safety/risk/loss in an organisation.

Figure 12

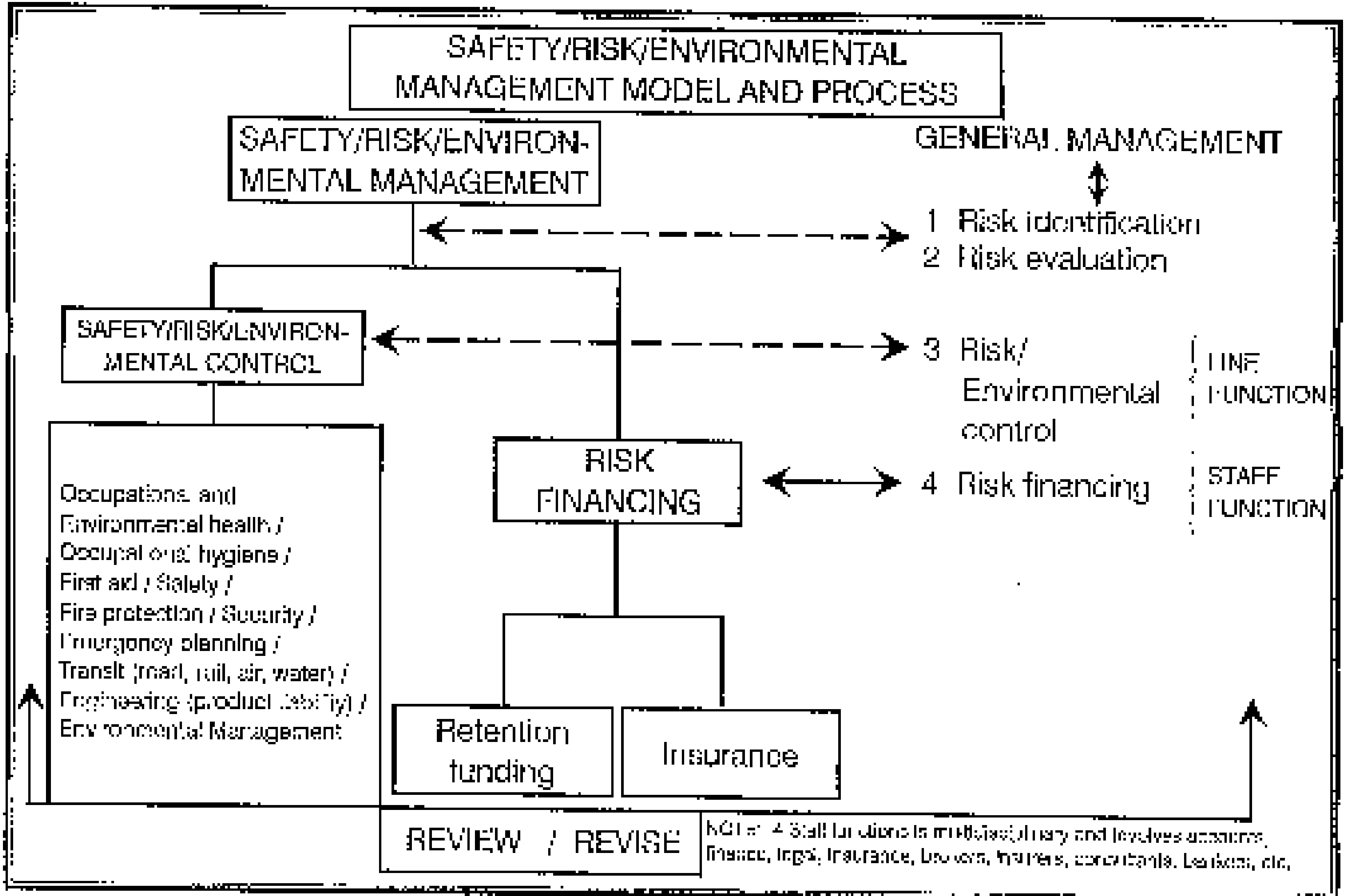

SAFETY/RISK/ENVIRONMENTAL MANAGEMENT MODEL AND PROCESS
SAFETY/RISK/ENVIRON-MENTAL MANAGEMENT
GENERAL MANAGEMENT
1 Risk identification
2 Risk evaluation
SAFETY/RISK/ENVIRON-MENTAL CONTROL
3 Risk/ Environmental control
LINE FUNCTION
RISK FINANCING
4 Risk financing
STAFF FUNCTION
Occupational and Environmental health / Occupational hygiene / First aid / Safety / Fire protection / Security / Emergency planning / Transit (road, rail, air, water) / Engineering (product liability) / Environmental Management
Retention funding
Insurance
REVIEW / REVISE

Figure 13

Guidelines for a Combined Safety, Risk, Loss and Environmental Assessment / Review Process

(Document all critical proceedings)

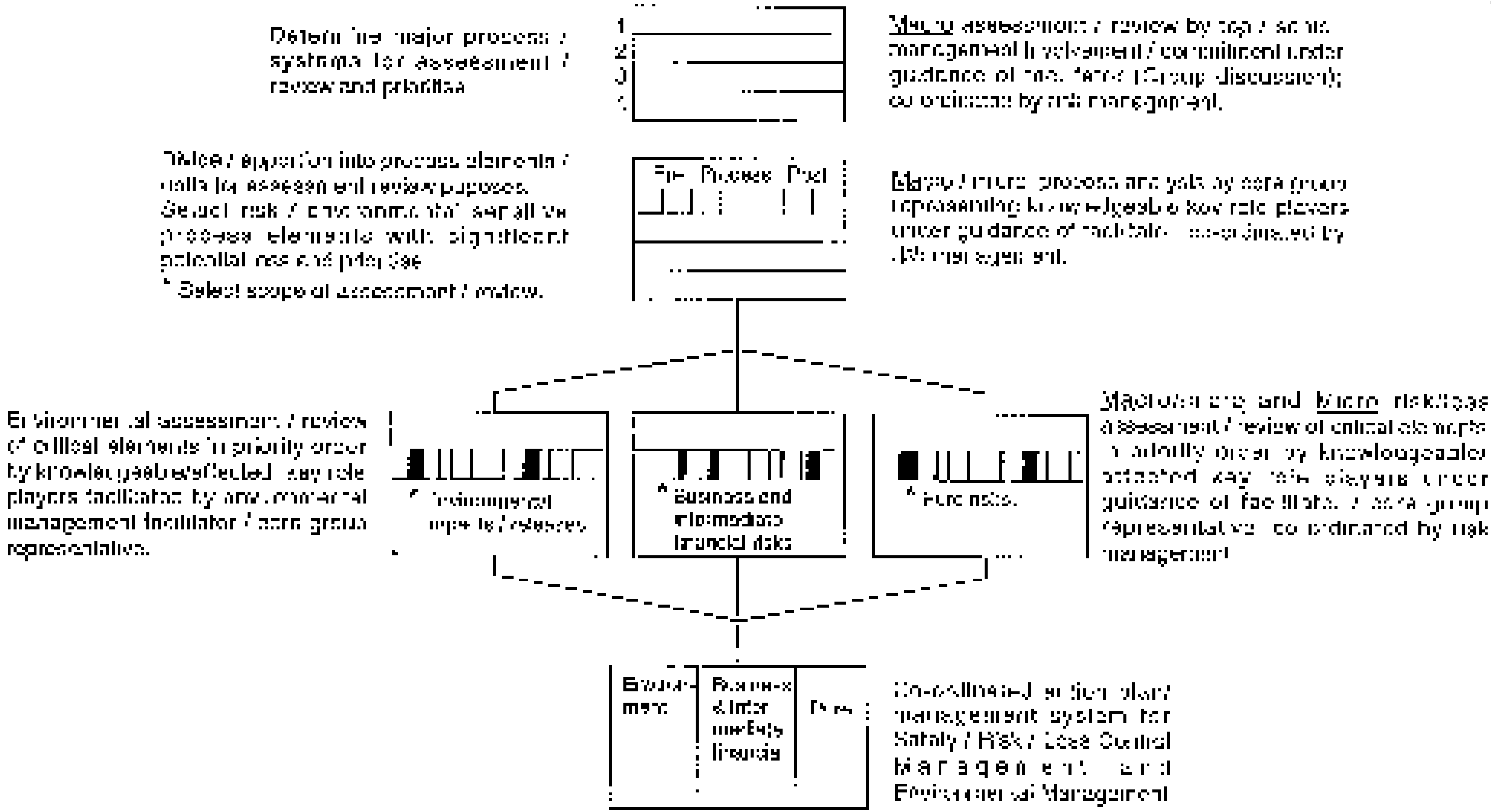


Figure 14

RISK/LOSS and ENVIRONMENTAL ASSESSMENT/REVIEW PROCESS MATRIX ANALYSIS

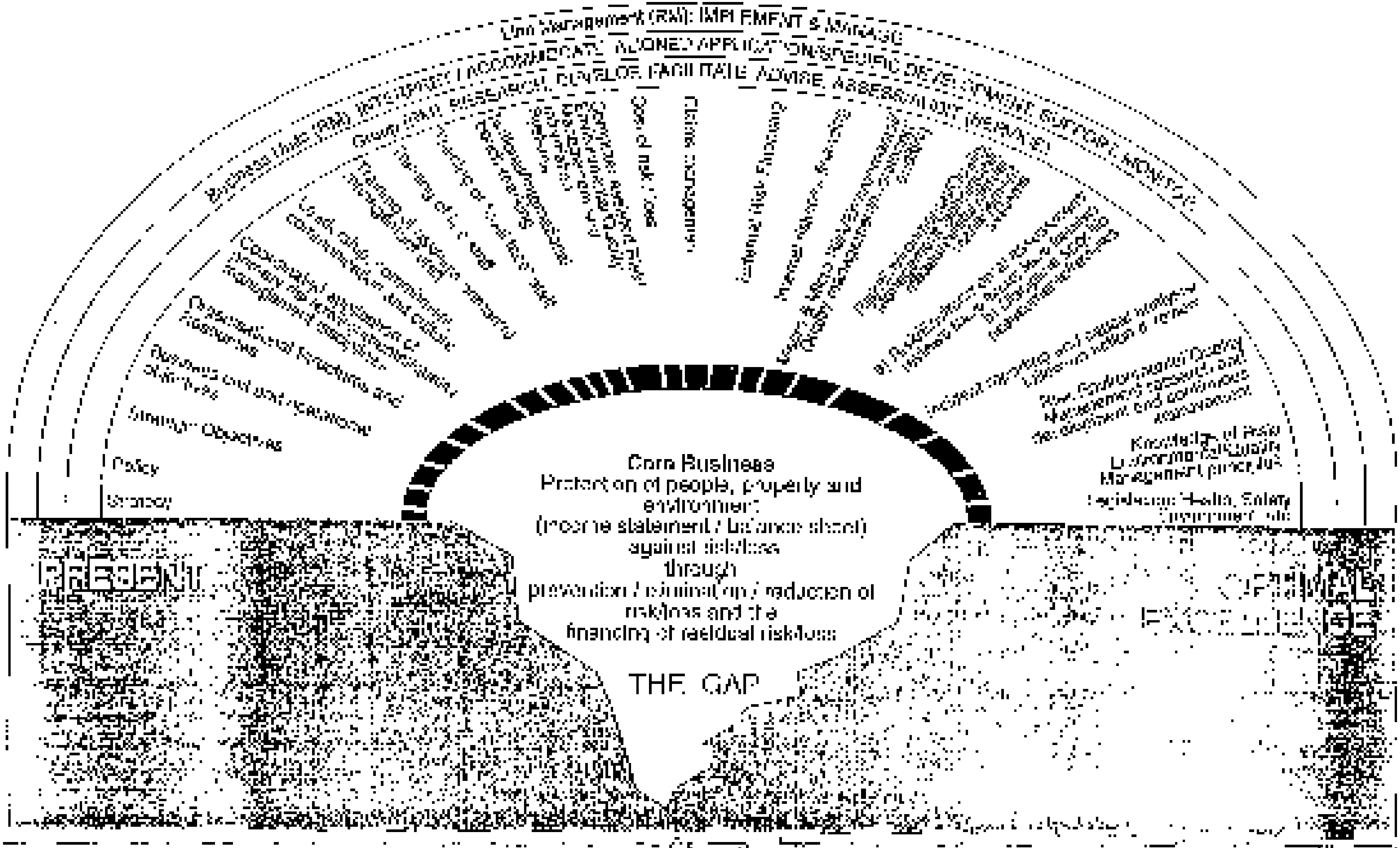
Macro / micro identification, evaluation and control

(Sample)

Figure 15

The Safety / Risk / Environmental / Quality Management Bridge/Model

(Keystones / Key result areas)



1996 CAPE TOWN

7 October - 9 October 1996
The Lord Charles Hotel, Cape Town, South Africa

Paper 9624

Jan Stuifmeel

Irregularities and accidents in the Railway System

CURRICULUM VITAE

Jan Stuifmeel

A Mechanical Engineer with over 15 years of experience in the field of rolling stock, infrastructure, train control systems and operations, related to railway safety.
Currently responsible for the safety evaluation of the Dutch Network including new line, e.g. the high speed lines from Amsterdam to Paris, Amsterdam to Cologne and the new freight line from Rotterdam to Germany, the Betuwe Line.

Qualitative and quantitative risk assessment / risk analysis / accident and incident investigation are his most prominent experience.

He currently is employed by Policy and Risk Management, Netherlands Railways, Railned Railway Safety.

Contents

Irregularities and Accidents in the Railway System

International Railway Safety Conference
october 1996
South Africa
Somerset West

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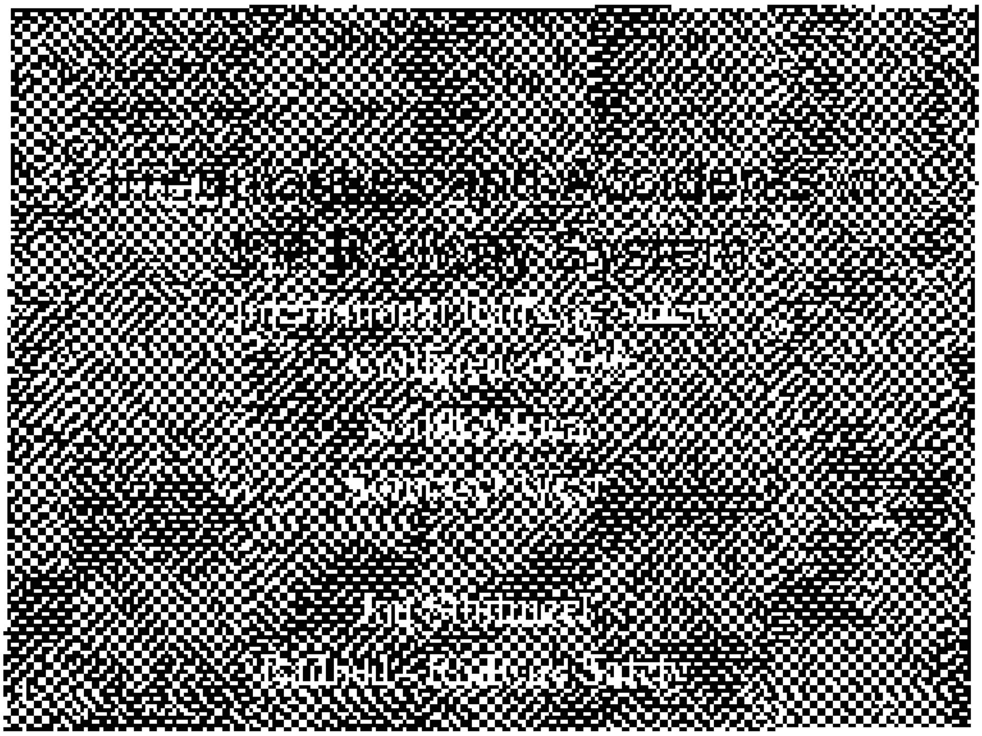
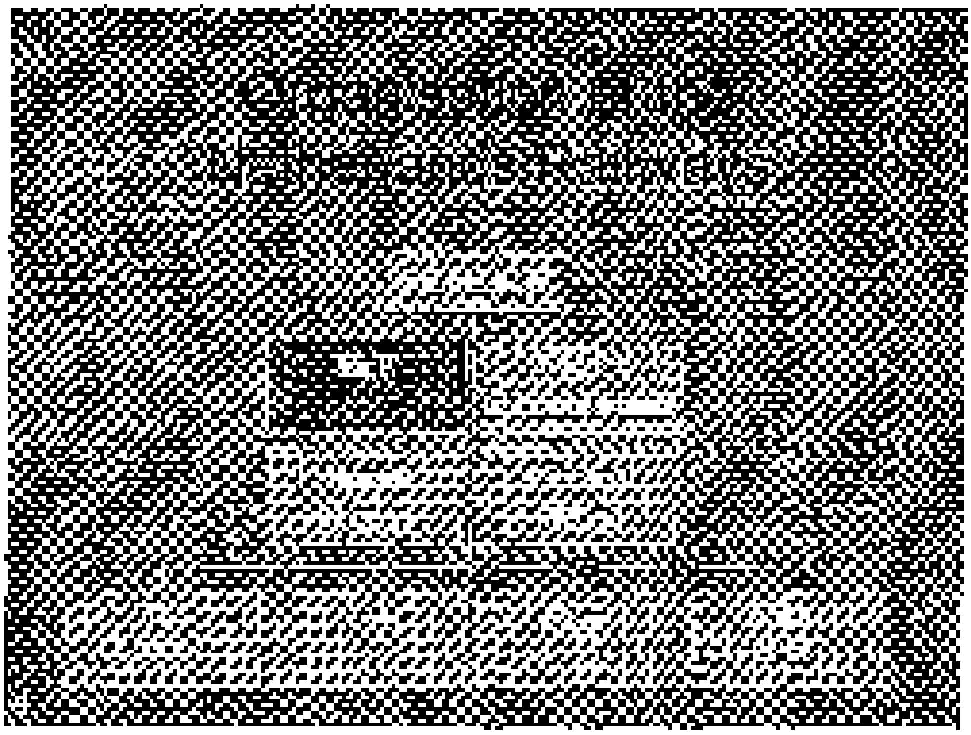
1 Introduction



This contribution of Railned to the International Railway Safety Conference 1996 consists of a general analysis of irregularities and accidents in the Dutch railway system. As part of his M.Sc. study at the Free University of Amsterdam, we asked Mr. Vivian Ravelli-Gee to perform a graduation assignment at Railned in Utrecht on this subject.

8. Railned

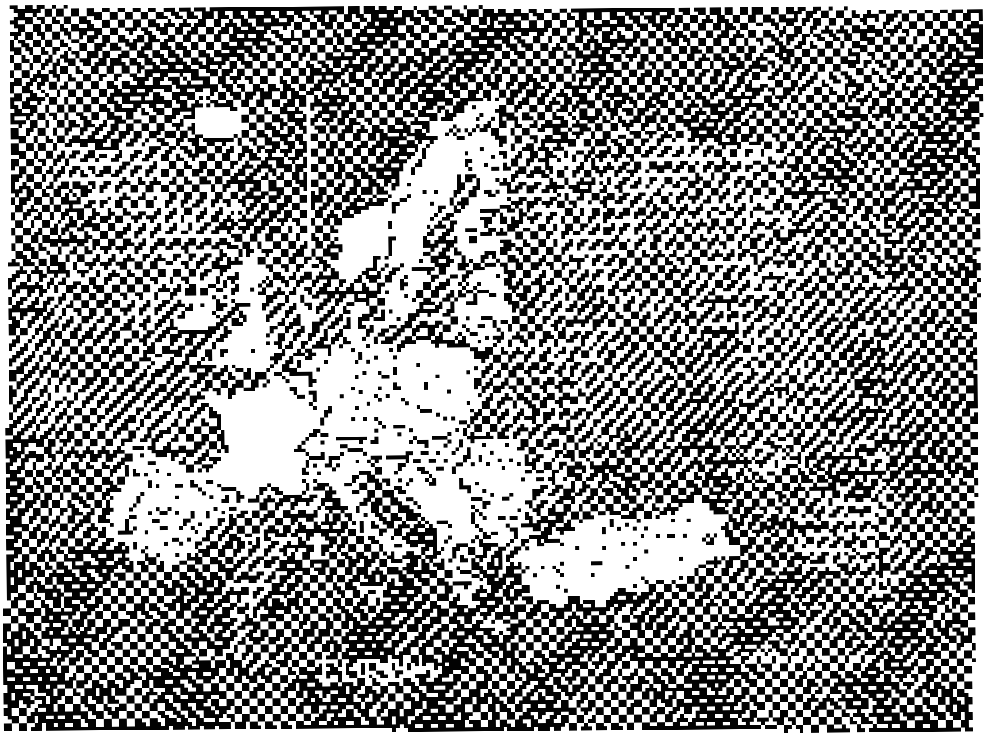


Railned is a subsidiary of the Netherlands Railways (NS) that provides an optimal and safe exploitation of the Dutch railway network. Our company consists of the following departments:

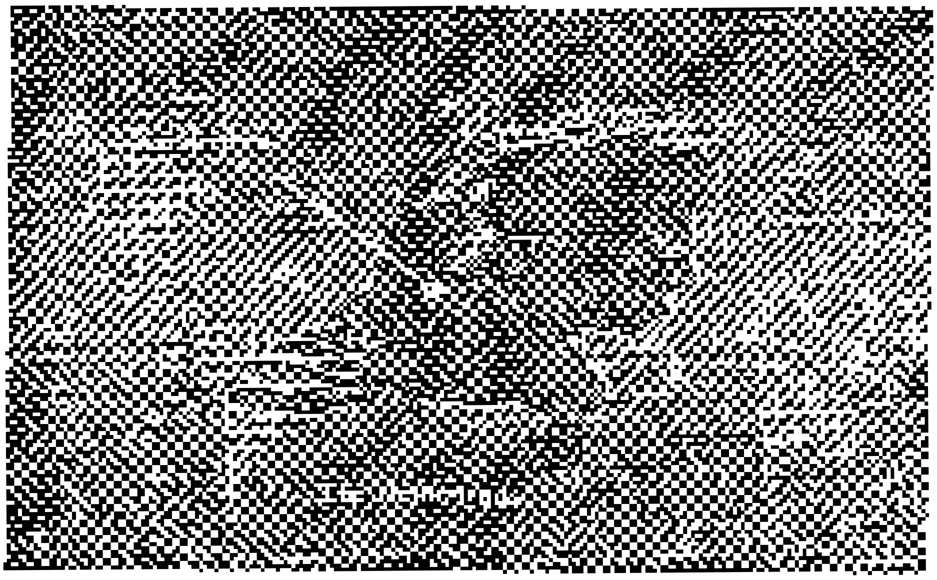
- Capacity allocation
- Capacity planning
- Innovation and
- Railway Safety

Capacity allocation [illegible] the capacity of the infrastructure.
Capacity planning gives the government advice about adjustments in the railway infrastructure.
Innovation [illegible] the capacity [illegible] of the infrastructure.
Railway Safety is responsible for [illegible] management, [illegible], inquiries into accidents [illegible] and regulations.

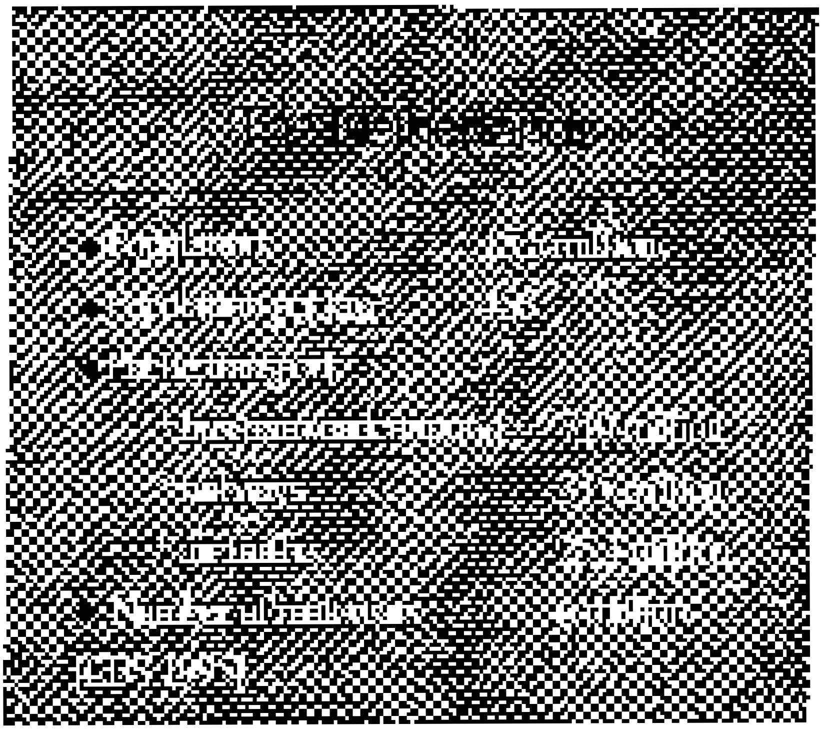
3 The Netherlands



The Netherlands (also known as Holland) is a small country in Western Europe

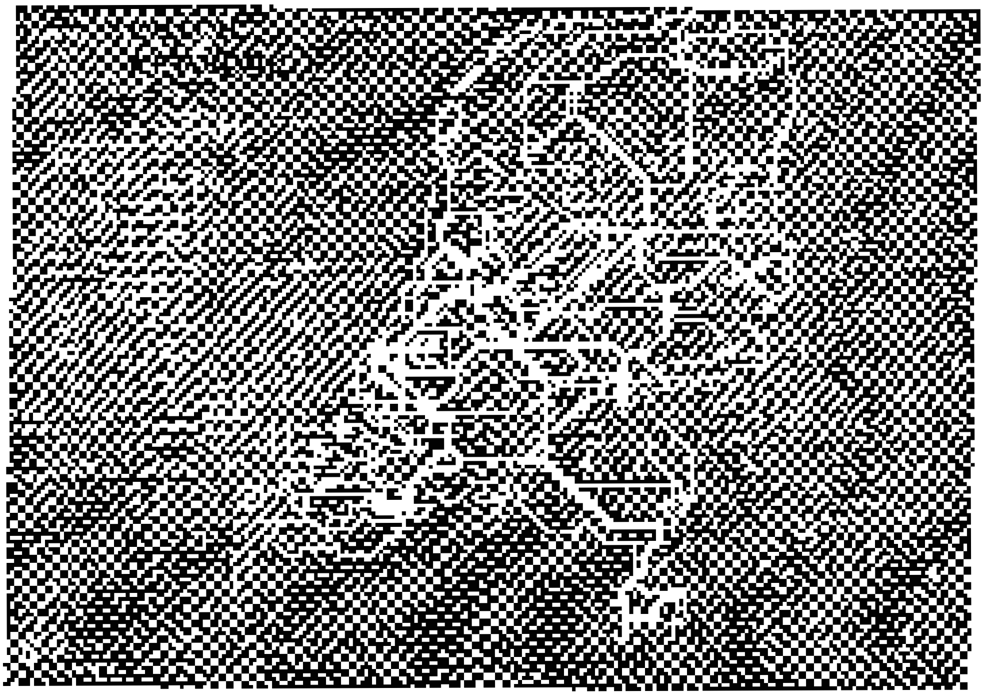


Windmills, wooden [illegible] tulips and [illegible] are [illegible]. Of course there is much more to tell about the Netherlands.



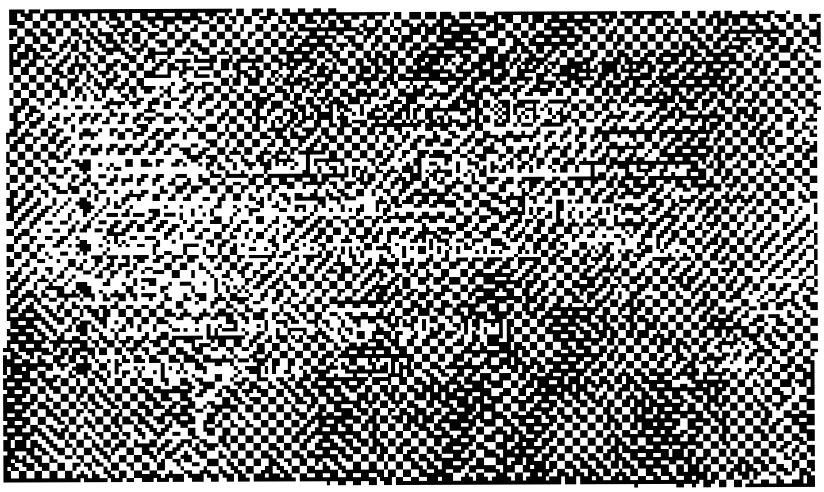
There are 15,5 million people living in the Netherlands. The population per square kilometre is 450.
In 199[illegible] bus, tram and underground [illegible] 7.0 [illegible] million passengers. In the same year Netherlands Railways had [illegible] million passengers and the air traffic 25,3 million.
By the end of 199[illegible] the total number of inhabitants was [illegible] million and at this moment still rising.

4 Netherlands Railways



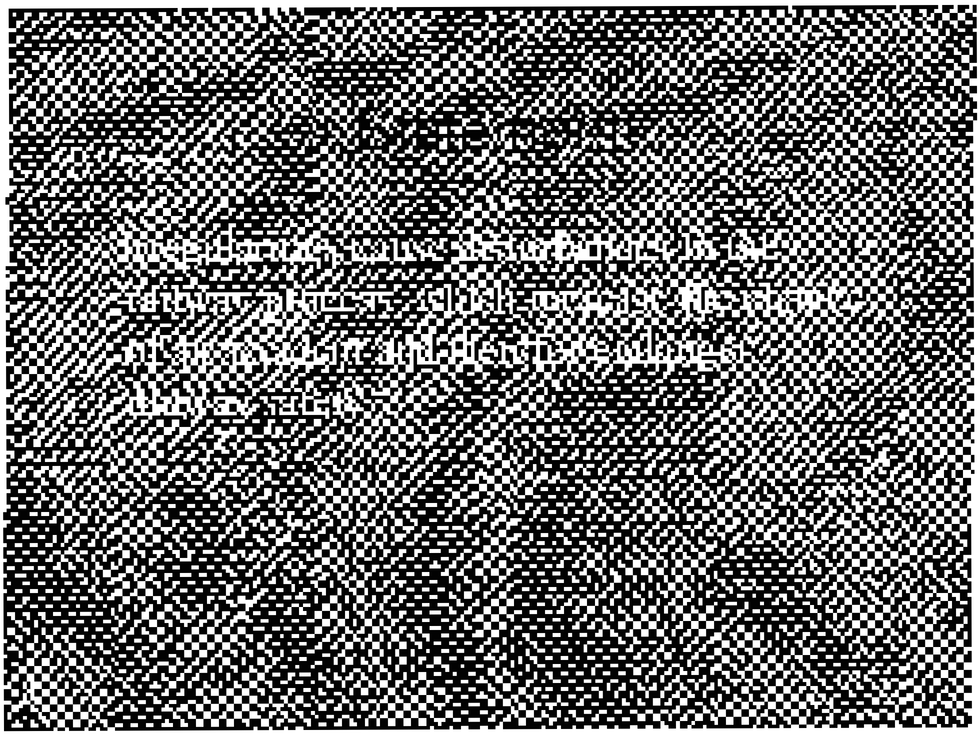
[illegible] network

Some examples of Netherlands Railways



- Averaged [illegible] last year (1998): 23 404 human years
- 14 billion passenger-kilometers
- 2 798 km of railway in exploitation
- 90 % of the rail infrastructure is provided with Automatic Train Protection
  The ATP system is not active below 40 kilometers per hour, so it is still possible to pass a signal at danger.
- 1,000,000 passengers are using the rail system daily
- Trains per day: 4,500.

[illegible] Irregularities and accidents



[illegible] in the railway system, which endanger the safety of railway personnel and/or passengers. [illegible]

[illegible]

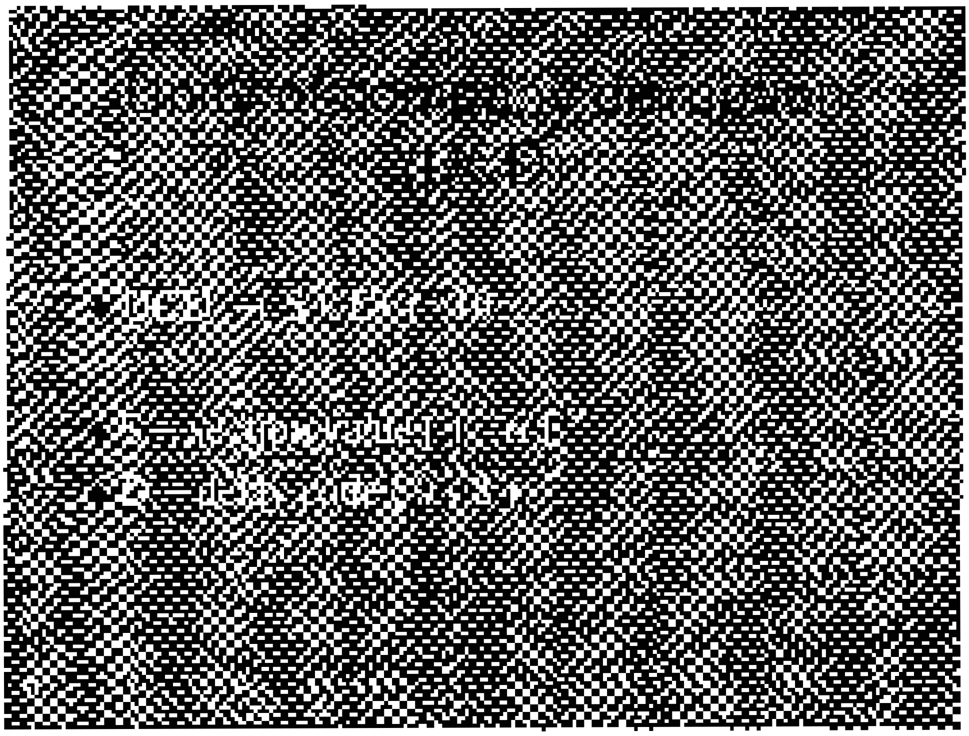
[illegible] which increase the chance of an accident [illegible]

[illegible] NS [illegible] between irregularities on the one hand and the occurrence of accidents on the other.
[illegible] consists of the following [illegible]:

- date and time of occurrence
- [illegible] the irregularity or accident
- [illegible]
- the place of occurrence
- [illegible]

1 NS [illegible]
2 NS [illegible]
3 NS [illegible]

4. NS [illegible]
5. NS [illegible]
- The [illegible] according to [illegible]
- The [illegible] irregularity [illegible]
- The number of [illegible]
- The delay that has been caused
- The [illegible] number of [illegible]
- The [illegible]



- The [illegible] of the irregularity or accident (D)

This [illegible] on the basis of the delays [illegible] and number of trains involved. This [illegible] value ranging from [illegible]

- The [illegible] (S)

The [illegible] assigned a value ranging from 1 to 6.

- The [illegible] (CCD)

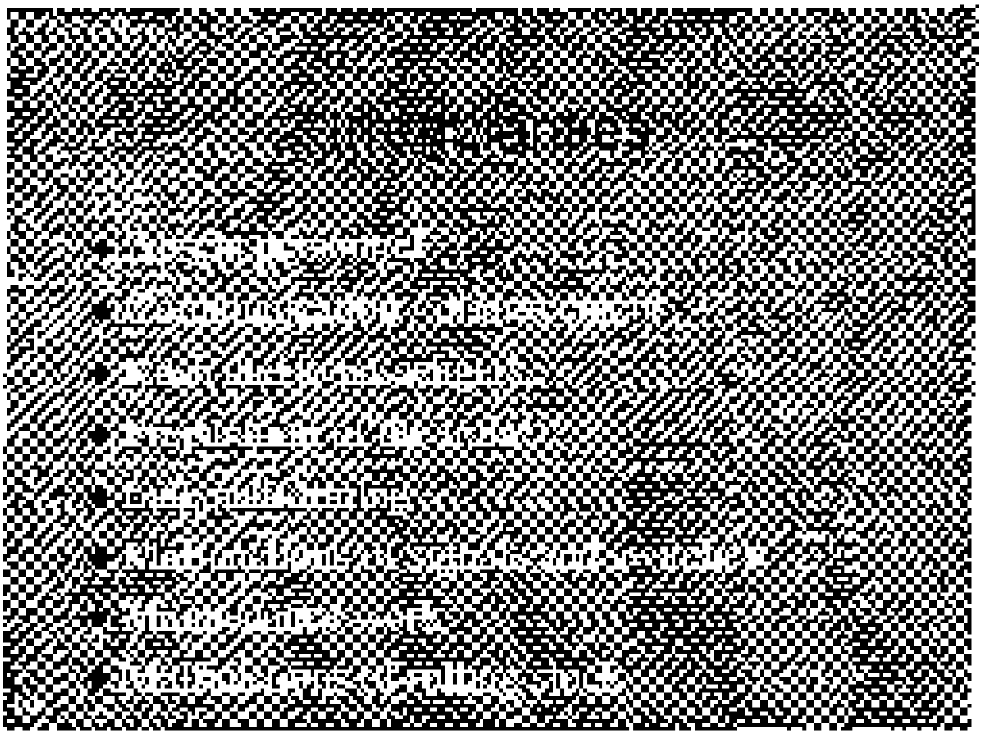
Each irregularity is assigned [illegible] measure that indicates the [illegible] by the irregularity. [illegible] according to the formula:

CCD = [illegible]

- [illegible]
- [illegible]

A [illegible]

[illegible]



- Maintenance work not finished in time

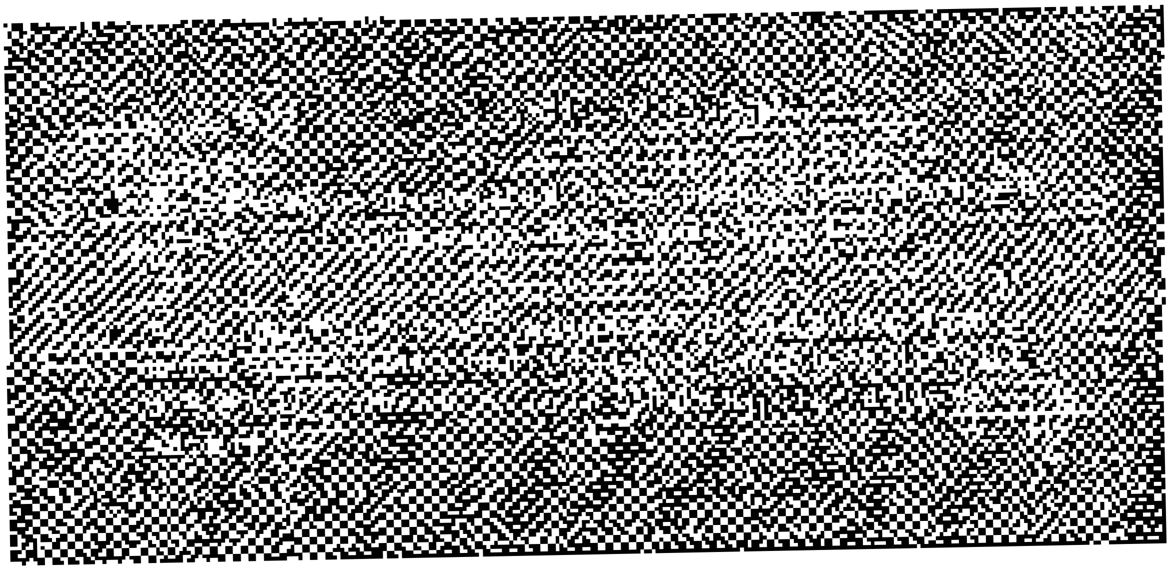
Irregularities of maintenance activities that take longer than planned are included in this category.

- Malfunctions of rolling stock (reliability of the technical subsystems in trains)

An example of a frequently occurring problem is the malfunction of doors of a train.

6 Conclusions

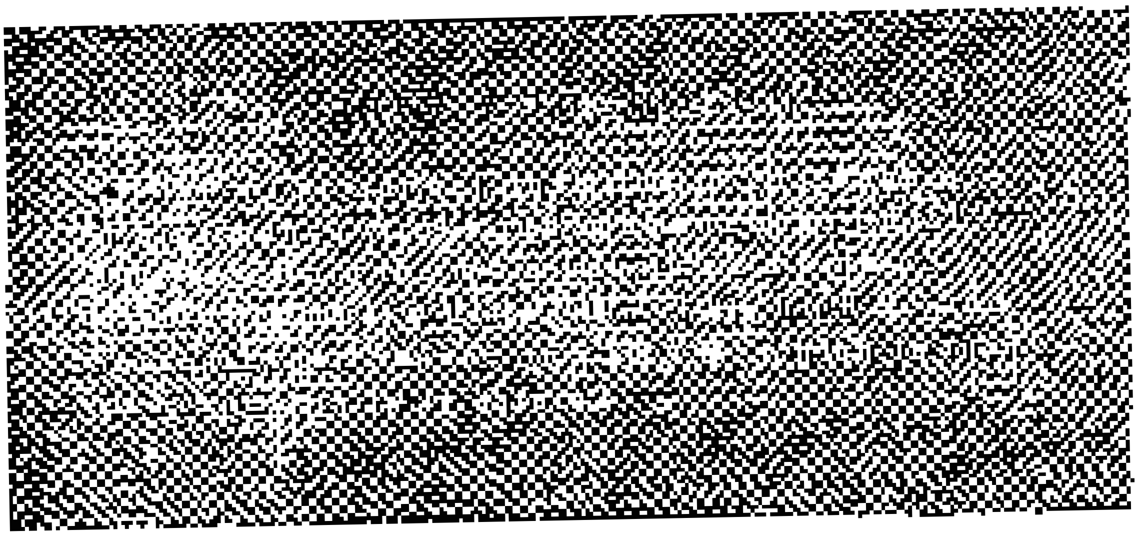
[illegible] ERTMS.
[illegible]



We apparently proved that a SPAD is preceded by a significantly high degree of [illegible] (ICTD).
This conclusion can not be reversed, leaving the following important result:

A high degree of [illegible] increases the probability of [illegible] of a SPAD, which [illegible] safety.
The next step is to determine which [illegible] lead to a high degree of [illegible].

The first [illegible] analysis.



The Statistical Analysis of the Irregularities and Accidents in the Railway System

by

V.R.C.K.H. Fa Si-Oen

Utrecht, April 1995

Railned Railway Safety

Preface

As part of my Mathematics study at the Free University of Amsterdam, I performed a graduation assignment at Railned B.V. in Utrecht. This report is the final result. I spent eight months at the Railway Safety department under the supervision of Ing. J.T.B. Stuifmeel and Drs. E. Griffioen.

This period has been a great learning process that I have experienced with great pleasure. Not only have I been able to put my theoretical knowledge into practice, but I also learnt a great deal about the railway system and what it is like to work in a real company.

I would like to thank Railned Railway Safety for giving me the opportunity to experience this and for making my stay a very pleasant one. In particular, my gratitude goes to Ing. J.T.B. Stuifmeel and Drs. E. Griffioen, who both have supported and guided me right from the beginning of this challenge. I also want to express my appreciation to B. Roos and all the other people who answered many of the questions I had about the railway system and the data available. Last but most certainly not least, I owe special thanks to my university supervisor, Dr. M.C.M. de Gunst, who supported me and has always been there when I needed advice on mathematical issues. Thank you to everyone who made this project possible.

[illegible]

Utrecht, April 19[illegible]

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Chapter 1

Introduction

1.1 The Netherlands Railways and Railned

Railned B.V. is a subsidiary of the Netherlands Railways (NS), that provides an optimal and safe exploitation of the Dutch railroad network. The company consists of the following departments:

- Capacity allocation
- Capacity planning
- Innovation
- Railway Safety

Capacity allocation controls the conflicts that arise when allocating the capacity of the infrastructure. *Capacity planning* gives the government advice about adjustments in the railway infrastructure. *Innovation* devises systems that will increase the current utilisation of the capacity of the infrastructure. My assignment was performed at the *Railway Safety* department. This department's mission is to prevent and reduce injuries and losses in the railway system. Railway Safety is responsible for policy management, norm establishment, inquiries into accidents, safety investigations and regulations. The place of Railned Ltd. within the Netherlands Railways concern is illustrated in figure 1.1 and some statistics of NS in 1995 are summarized in table 1.

Total operating revenue	[illegible] millions
Averaged staffing	[illegible] man-years
Passenger-kilometers	[illegible] millions
Tonnage-kilometers	3047 millions
Railway length in exploitation	2739 kilometers
Level crossings	3063 units (of which 1341 manned)
Stations for passenger transport	372 units
Seats	196 thousands
Passenger stock	2612 vehicles
Freight stock	3287 vehicles

Table 1

1.2 Description of the assignment

Some irregularities occur in the railway system, which endanger the safety of railway personnel and/or passengers. Examples of such irregularities include malfunctioning of switches and signals or delays. In a few cases an irregularity can lead to a crash or derailment, which in turn may result in casualties and damage to equipment.

As a result of this the thought has been put forward that certain relationships exist between the irregularities on the one hand and the occurrence of accidents on the other. This phenomenon is also expressed as *safety by timetable*, which states that no accidents can and will occur if all trains are operating exactly according to the timetable.

The main purpose of the assignment is to statistically substantiate this thought and to make statements about the extent of railway safety. Through this, preventive actions can be taken to decrease risks. Until now the available data have never been investigated in a mathematical/statistical way. Therefore, this assignment can also be thought of as exploratory research that will enable further statistical surveys in this field in the future. In addition, this research is also meant to serve as a guiding principle for the policy and risk management by Railned.

1.3 An overview of the report

This report has been organised in such a manner, that readers without a statistical background can still follow the general setup of the survey. In the next chapter we will describe how the data have been acquired. We will also describe what kind of data we have at our disposal. In chapter 3 the reliability of these data is investigated. Chapter 4 presents the main questions and the approach that will lead to an answer to these questions. Chapter 5 summarizes the findings of the analysis and a final discussion is given in chapter 6.

The appendices are meant for readers familiar with statistics. Appendix A is concerned with the statistical analysis of the data. Appendices B, C and D are meant for the more mathematically interested readers. These appendices contain some of the mathematical theory that forms the basis of appendix A. Appendix E consists of the figures that are part of the statistical analysis.

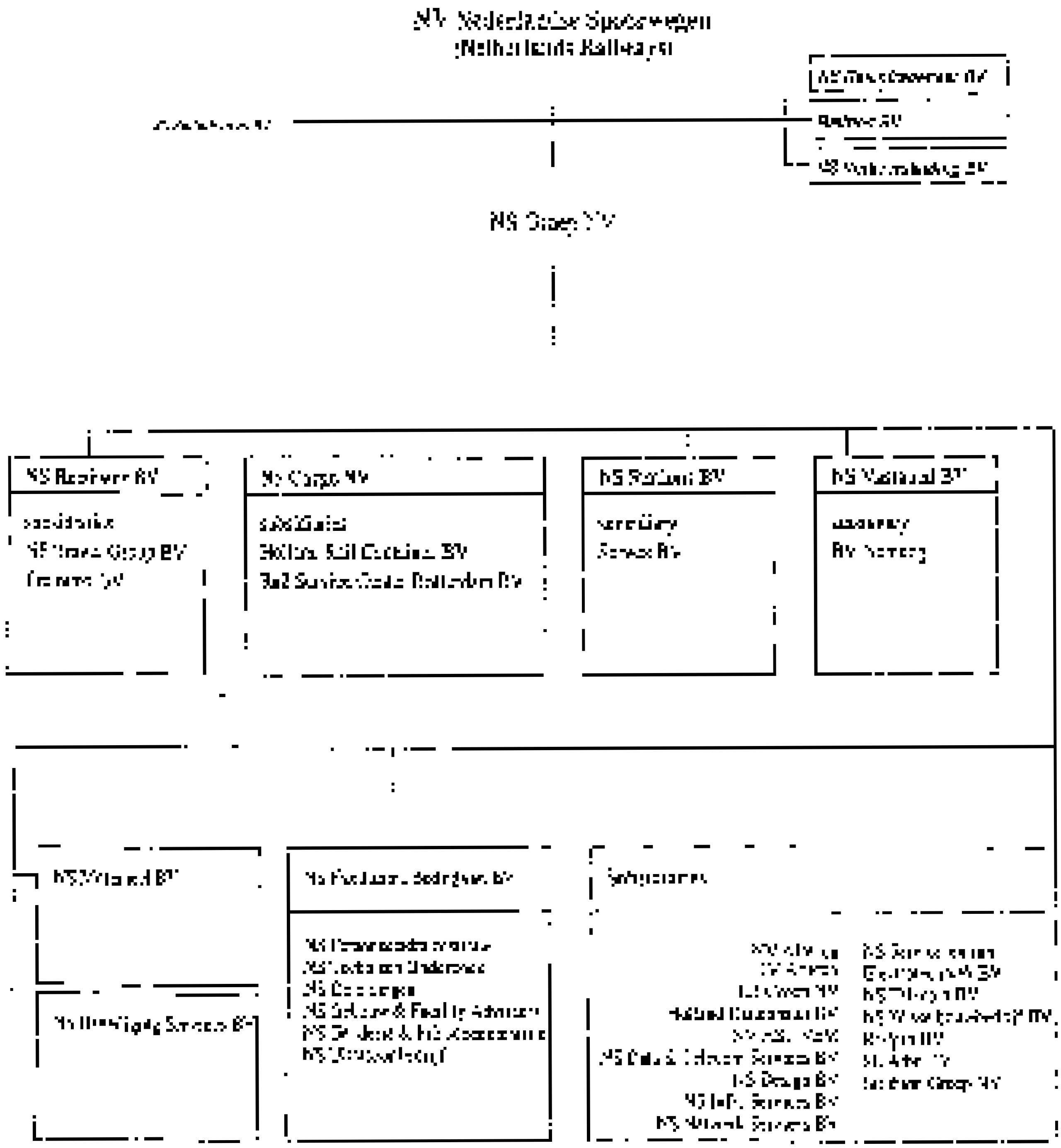

Figure 1.1: The Netherlands Railways Concern

Chapter 2

The data

The irregularities and accidents that take place in the railway system are registered daily by means of a log book at the traffic controls all over the country. The input of these registrations takes place at both the traffic controls and at the LCVL[1]. Every month the registrations are then electronically passed on to Railned. Serious accidents are thoroughly investigated, resulting in an elaborate report. These investigations are grouped in classes ranging from 1 to 4, where class 1 includes the very serious accidents. The purpose of the investigations is to determine the risks, the causes and the consequences of the accidents. A method has been developed to evaluate the risk, the so-called Risk Analysis Method (RAM). At the end of the reports, recommendations are made to prevent a recurrence of the accident.

The above procedures provide Railned Railway Safety the data it needs to perform risk analysis. Until now analysis of these data has been restricted to frequency and trend research. In this report we will use more formally statistical methods to analyse the data. The data are filed in a database, called MISOS[2]. MISOS contains circa 220.000 irregularities, registered in the years 1989 until 1995. Further, the database contains circa 4500 accidents, registered in the years 1981 until 1994. For practical reasons, we will only use the data in the years 1992 until 1995. The actual analysis will be carried out with the statistical computer package SPSS for windows, version 5.1.2.

Every registration consists of the following information :

1. The date of occurrence.
2. The time of occurrence.
3. The traffic control that registered the irregularity/accident.
4. The moment of occurrence (morning rush-hour, evening rush hour or off peak hours).
5. The place of occurrence.
6. The category the registration is divided into. There are five categories, namely
   (a) NS Traffic Control
   (b) NS Travellers

[1] Rural Communication Center Traffic Control
[2] Management Information System Irregularities Railway Safety

(e) NS Cargo

(f) NS Equipment

(g) NS Rail Infra Group

7. The subcategory the registration is divided into.
   Every category is classified further according to the nature of the incident.

8. The area in which the irregularity/accident took place.

9. The number of the train that was the direct cause.

10. The delay the train has incurred.

11. The equipment number of this train.

12. The inquiry number of the incident.

13. The delay code of the irregularity/accident (d).
    This d is determined on the basis of the delays, the nature and the number of trains involved. This code has a value ranging from 0 to 8.

14. The section value (s).
    The place of occurrence in the railroad network is assigned a value ranging from 1 to 6.

15. The entity of nuisance disruption (ned).
    Every registration is assigned a measure that indicates the extent of disruption, caused by the irregularity. This value is computed by means of the delay code and the section value according to the formula

$$ned = \frac{s \times 2^{d}}{10}.$$

16. A description of the incident.

17. Causes of the incident.

The database contains more detailed information about the accidents for which an investigation has been set up. For instance, information about personal circumstances, injuries, the weather at the time of the incident, cost information and proposed actions or actions that are to be carried out.

For our analysis we have selected a number of irregularities that occur most frequently. These are

1. <u>Absent personnel</u>
   These irregularities include for example cases where the train inspector, driver, shunter or platform inspector is not at his or her post in time.

2. <u>Communication disturbance/disagreement between personnel</u>
   These irregularities include for example cases where there is a misunderstanding or disagreement between the driver and the shunter. Another example is personnel that has not been informed correctly.

3. <u>Delays due to passengers</u>
These irregularities include for example cases where there is a great rush of passengers. But also cases where disabled passengers have to be helped to get into or out of the train are included. Another example is when the train is waiting for luggage to be loaded or unloaded.

4. <u>Irregularities with/due to preparation of the train</u>
These irregularities include for example cases where trains have been wrongly formed. Other examples are when a full or partial brake test has to be performed, or when a journey report has to be made.

5. <u>Late platforming</u>
These irregularities include cases of delay when bringing trains into the stations.

6. <u>Malfunctions of signals</u>
These irregularities include for example reportings of occupied tracks or signals that are out. Another example are signals that stay in the stop position.

7. <u>Malfunctions of switches</u>
These irregularities include for example switches that do not respond or are not under control.

8. <u>Maintenance work not finished in time</u>
Irregularities of maintenance activities that take longer than planned are included in this category.

9. <u>Malfunctions of rolling stock</u>
An example of a frequently occurring problem is the malfunction of the doors of a train.

[1] A selection has been made by means of the category/subcategory number and in some cases of the description of the incident.

Chapter 3

The reliability of the data

Before we start with the actual analysis, we investigate the reliability of our data. It is important to know how the data reflect the reality. In order to investigate this aspect, we compare our data with the measurements that were made by ROVER [1]. This association counted the number of arriving and departing trains that were delayed at a number of stations. The research by ROVER was performed in the period of September 1993 to February 1994. Every station was observed 4 times (on 4 different days): two observations during the morning rush-hour (7.00-10.00) and two observations during the evening rush-hour (16.00-18.00). All observations were made on a Wednesday. The stations were chosen in such a way that almost all train series on the Dutch railroad network were observed on at least one point of their route. Trains were observed at the following stations :

- Amersfoort
- Amsterdam CS
- Eindhoven
- Leiden
- Rotterdam CS
- Utrecht CS
- Zwolle

Due to the limited time, we only consider the stations Amsterdam CS, Zwolle, Leiden and Rotterdam CS. In order to be able to make a comparison, we have to use our data to calculate the numbers of the same quantities as ROVER has done. This is done as follows. For every station all numbers of the trains that arrive and depart during the time intervals 7.00-10.00 and 16.00-18.00 are determined. On one day these numbers are unique. Next a selection from the registrations has been made, based on the date/time of the registration and the number of the train involved. For example, for the station Amsterdam CS we select all trains that incur an irregularity on an ROVER observation day, and pass Amsterdam CS on their way. However, not all these registrations should be used when determining the number of arriving and departing trains which are delayed at the stations. For instance, if a train is

[1] Association for travellers and public transport

delays after it has passed Amsterdam CS, then it will not have been observed by ROVER. After filtering out these cases, the remaining irregularities have been divided into three classes:

- a. in time : 1 minute early, in time or maximum delay of 2 minutes
- b. slightly delayed : delay of 3, 4, 5 or 6 minutes
- c. seriously delayed : 7 minutes delay or more

In dividing the cases, the following assumption has been made:

"If a train travels from A to B and is delayed in A, then this train will arrive and depart with (approximately) the same delay in B."

For trains with a serious delay, this is a reasonable assumption. For trains with a slight delay it is not, because it is possible that a few minutes of delay is made up (see 2 below). When comparing our numbers with the ROVER numbers, we can expect certain differences. These are caused by the way our registrations are made.

1. Only irregularities that cause a delay of at least 3 minutes are registered in the log book. Trains that have not been involved in an irregularity will not be registered. Hence, the numbers of the class 'in time' are not suitable for comparison.

2. Trains that have incurred a delay of a couple of minutes are often not registered. The traffic controllers can judge from experience whether a train will make up a few minutes of delay or not. ROVER, however, does register this train. The numbers of the class 'slightly delayed' are therefore not suitable for comparison either.

3. An irregularity is only registered once. For instance, if train II is delayed because of an irregularity caused by train I, then only one registration will be made for train I, no matter how many trains were delayed because of train I. ROVER, however, does register all delayed trains.

4. If the doors of a train are closed (open), then ROVER considers this train as 'departed' ('arrived'). NS, however, considers a train 'departed' or 'arrived' when the train has passed a particular signal.

Finally, we also note that ROVER, due to lack of personnel, has not been able to observe all trains. About 50% of all trains have actually been observed.

Given all these considerations, we may conclude that a somewhat meaningful comparison can be made on the basis of the numbers of class c, the serious delays. The results are summarised in table 3[2]. In this table we see that ROVER registered more seriously delayed trains arriving than NS at all four stations. At the stations Leiden and Roosendaal the numbers differ by approximately a factor of 2. If we look at the departures, we see that only Zwolle and Leiden show differences. In Leiden, it is ROVER which registered more delayed trains again. In general we may conclude that ROVER registers more serious delays than NS does. In some cases this is about twice as much. This difference is most likely caused by the way the irregularities are registered, and perhaps also by registration errors, since the registration is still done by hand. The differences among stations can be explained by the fact that some traffic controls register better than other controls. Hence, if we wish to determine the number of serious delays by means of the registrations made by NS, we will have to keep

[2]The sum of the percentages in the NS column does not have to equal 100 % (see 1).

in mind what these numbers mean and how they were obtained. The fact that they are in general somewhat lower than the ROVER numbers does not necessarily mean that they are unreliable. In what follows we will use the NS registrations for our statistical analysis.

			NS		HOVER	
Amsterdam CS						
	arrivals					
		in time	4	(1%)	256	(71%)
		slightly delayed	[illegible]	([illegible])	24	(17%)
		seriously delayed	13	(2%)	[illegible]	(3%)
	departures					
		in time	4	(1%)	380	(92%)
		slightly delayed	6	(2%)	28	(7%)
		seriously delayed	12	(3%)	12	(5%)
Zwolle						
	arrivals					
		in time	2	(1%)	26	(83%)
		slightly delayed	4	(2%)	30	(12%)
		seriously delayed	5	(3%)	2	(5%)
	departures					
		in time	5	(1%)	137	(82%)
		slightly delayed	2	(1%)	31	(16%)
		seriously delayed	7	(3%)	3	(2%)
Leiden						
	arrivals					
		in time	2	(1%)	189	(76%)
		slightly delayed	3	(1%)	51	(15%)
		seriously delayed	9	(3%)	22	(9%)
	departures					
		in time	3	(1%)	[illegible]	(69%)
		slightly delayed	3	(1%)	52	(23%)
		seriously delayed	12	(4%)	17	(8%)
Amsterdam CS						
	arrivals					
		in time	5	(1%)	[illegible]	(67%)
		slightly delayed	10	(3%)	92	(21%)
		seriously delayed	10	(4%)	33	(7%)
	departures					
		in time	3	(1%)	366	(92%)
		slightly delayed	10	(3%)	56	(15%)
		seriously delayed	10	(4%)	13	(4%)

Table 2

Chapter 4

The experimental design

4.1 The main questions

Nearly half of the investigations that have been carried out by NS have been cases of "Signal passed at danger" (SPAD). A SPAD leads to a dangerous situation. Most of the very serious accidents, which occur approximately every 5 years, are preceded by a SPAD.
In order to investigate the relationship between the irregularities and the extent of railway safety, we have therefore decided to focus on these SPADs. The questions we will try to answer are :

Is a SPAD preceded by an increased degree of disturbances and irregularities ?
If so, are there any specific irregularities involved?

4.2 The approach

In order to find an answer to the questions stated in the preceding section, we proceed as follows. We select a number of districts for further investigation. These are as follows

- Utrecht
- Amsterdam
- Rotterdam
- Den Haag
- Amersfoort
- Eindhoven
- Maastricht
- Zwolle
- Roosendaal.

For every district we examine all SPAD investigations between the years 1991 and 1993. Since the date, district and time of occurrence are mentioned for every SPAD, it is possible to determine the amount of disturbances preceding the SPAD in that district. We determine this amount of disturbances by computing the total amount (units of company disruption) that was registered during the four hours preceding the SPAD. Here we include all registered irregularities, not only those mentioned in chapter 3. This is done for every SPAD in all districts. In this way, every SPAD i is assigned a value, say X_i (for the i-th SPAD), which represents the amount of disruption that preceded the SPAD with case number i. What we would like to do now is to compare this value X_i with another value of ucd which represents the degree of disturbances under exactly the same circumstances, but with the difference that these disturbances are not followed by a SPAD. We will denote this value by Y_i. The computation of X_i and Y_i is best illustrated by an example.

Suppose a SPAD with case number i took place in Amsterdam on April 15th 1991, which was a Monday at 19.00 h. The value of X_i is then computed by determining the total amount of ucd's that was registered in the district of Amsterdam on April 15th 1991, from 15.00 h till 19.00 h. For the computation of the value of Y_i, we select all Mondays in 1991 on which no SPAD occurred. For every selected Monday we compute the total amount of ucd that was registered from 15.00 h till 19.00 h, again only in the district of Amsterdam. The value of Y_i is then computed as the mean of all these values.

In this way every amount of ucd during the four hours preceding a SPAD is paired to a value of the amount of ucd during the same hours but under 'normal' circumstances (and not preceding a SPAD). By means of pairwise comparison of these values, we hope to obtain information about the difference in degree of disturbances for time intervals preceding and not preceding a SPAD. This seems to be a fair comparison, since we examine the SPADs and ucd values per district. Also, we only consider the irregularities that took place during the four hours preceding the SPADs, since it is not very likely that an irregularity will lead to a SPAD say 24 hours later. Furthermore, the values of the Y_i's were determined for time intervals that were identical to the intervals that preceded the SPAD. In this way circumstances (such as the time table) will remain unchanged as much as possible. The total number of SPADs in the nine districts considered between the years 1991 and 1993 is 293. The computed values can be organised as in the following scheme:

	X	Y
SPAD 1	X_1	Y_1
SPAD 2	X_2	Y_2
SPAD 3	X_3	Y_3
⋮	⋮	⋮
SPAD 293	X_{293}	Y_{293}

To find an answer to the first question stated in section 4.1, we investigate whether the values in the second column (X) differ significantly from the values in the third column (Y). The statistical analysis of these values is described in chapter 5.

Chapter 5

Summary and Conclusions

The aim of this survey is to statistically substantiate the following statement :

"Irregularities cause disturbances in the railway process, which increase the chance of an accident and thus endanger railway safety."

This statement is very plausible. Our goal is to use the data registered by NS to statistically prove that a relationship actually exists between irregularities on the one hand and the occurrence of accidents on the other. Almost all serious accidents that occur every five years are preceded by a so-called "Signal Passed at Danger" (SPAD). Therefore we have decided to focus our survey on these SPADs. Our approach was as follows. We selected nine districts for further examination. The total amount of SPADs in these districts between the years [illegible] and [illegible] is [illegible]. For all these SPADs we have determined the degree of disturbances (ucd) preceding the SPAD. This degree of disturbances is determined on the same day, in the same district and during four hours preceding the SPAD. The obtained value for the company disruption is then compared to a 'normal' value of the ucd under identical circumstances, that is not preceding a SPAD. In appendix A we statistically investigate whether the first value differs significantly from the second. The conclusion of this chapter is the following :

> A SPAD is preceded by a significantly high degree of company disruption (ucd).

This conclusion can and may be reversed, giving the following important result :

> A high degree of company disruption (in terms of ucd) increases the probability of occurrence of a SPAD, which in turn endangers railway safety.

This answers the first question of section 4.1 . The next step was to determine which irregularities cause a high degree of company disruption. The irregularities considered were those listed in chapter 2. In order to determine which irregularities cause a high degree of company disruption, we computed the total number of the registrations of the different irregularities per month between the years [illegible] and [illegible]. The total amount of ucd that was registered per month was also determined. Having computed these numbers, we derived an equation which describes the relationship between the ucd on the one hand and the irregularities that describe this ucd best on the other (see chapter 5). The irregularities that describe the ucd best appear to be the following:

- Absent personnel.
- Rush due to passengers.
- Work not finished in time.
- Malfunctions of rolling stock.

In other words, a high degree of company disruption is mainly caused by these irregularities. It also appeared that a decrease in the number of absent personnel and malfunctions of rolling stock will have the greatest effect on the company disruption. Putting all results together, the final conclusion of this analysis becomes:

> Absent personnel, rush due to passengers, maintenance works not finished in time and malfunctions of rolling stock are the main causes of a high degree of company disruption. This high degree of company disruption increases the chance of a SPAD, which in turn endangers railway safety.

Chapter 6

Discussion

The result of the preceding chapter can be used as follows. It is known that company disruptions lead to costs for the NS concern. Hence, investments that decrease the degree of company disruption will be recovered. This decrease will improve the product that the NS concern delivers to its customers, since the punctuality of the trains will also improve. In turn, this will encourage more people to use the train as a means of transportation. Most importantly, the investments that are made will result in a higher degree of railway safety. This is where the conclusion of the preceding chapter is used. The decrease of the degree of company disruption will decrease the probability of occurrence of a SPAD, and thus increases the railway safety. Thus the increase of railway safety is an extra profit of the investments made to improve the punctuality. All this can be made more precisely by means of certain ratios. At the moment research is in progress to determine these ratios.

This survey has been the first mathematical/statistical analysis of the data registered by the Netherlands Railways. These data could be used to answer many interesting questions like the one raised in this report. Other questions which I had raised but could not answer due to a lack of time are the following :

1. Which accidents/irregularities occur most frequently and at what time?
   The time aspect of this question can be specified by the time of the day, day of the week or month of the year.

2. Is there any relationship between the occurrence of accidents/disruptions and weather circumstances? If so, what does this relationship look like?

3. Which accidents/irregularities occur most regularly in which place?

4. Is there any relationship between the occurrence of different accidents/irregularities in certain districts and a number of aspects of that district?
   Aspects that may be relevant are for example:

   - the number of signals in a district.
   - the number of barriers/level crossings in a district.
   - the number of stations in a district.
   - the number of movement inspectors in a district.
   - the number of boarding passengers in a district

Some of these questions can probably be answered with experience and some common sense; others may not. For example, it is well known that the punctuality of the trains is better in the summer than in the autumn. This is due to falling leaves that cause slippery tracks. However, we still want to have some (statistical) justification for the statements we make. We also remark that the derivation of the equation for the ucl in Appendix A was based on one criterion. Other criteria are available and can also be used to derive a, possibly different, equation for the ucl. We may conclude that the available data will enable further statistical analysis in the future.

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Appendix A

The statistical analysis

A.1 Introduction

We are dealing with two data vectors, $X=(X_1,\ldots,X_{333})$ and $Y=(Y_1,\ldots,Y_{333})$, of which the corresponding elements are paired. The Y_i are defined as

$$Y_i = \frac{1}{n_i}\sum_{j=1}^{n_i} Y_{ij},$$

where Y_{ij} is the jth value of the [illegible] not followed by a SPAD for case i, and n_i is the total number of these values for case i. The variables corresponding to the different cases are assumed to be independent, as are $X_i, Y_{i1},\ldots,Y_{in_i}$ for $i=1,\ldots,n$. We remark that this independence assumption is very reasonable. At the end of each day all trains are returned to the right places and we may assume that every day begins with a fresh timetable. Hence we may indeed assume that the variables are independent. We also assume that for each i, $Y_{i1},\ldots,Y_{in_i}$ are identically distributed and that X_i has the same distribution as the Y_{ij}, except for a possible scaling factor. The latter is suggested by the fact that for this type of data the coefficient of variation seems to be relatively constant.

Our goal is to test whether the X_i are significantly higher than the Y_{ij}. Since Y_i has the same expectation as the Y_{ij}, this question can also be translated in terms of the location of the distributions of X and Y. Suppose the stochastic vectors X and Y have expectation vectors

$$EX = \mu_1 \quad \text{and}$$
$$EY = \mu_2.$$

The hypothesis we wish to test then becomes

$$H_0: \mu_1 - \mu_2 = 0\,, \qquad \text{(A.1)}$$

that is, the hypothesis of no difference in mean.

A.2 Independence and identical distribution

Before we can proceed with tests for difference in location, it would be helpful to know whether the differences $Z_i = X_i - Y_i$ are independent and identically distributed. From the above it

It seems that the Z_i are independent i.i.d. The second assumption, however, does not seem to be reasonable. Figure 1 shows a sequence plot of the means and standard deviations of the 393 samples of Y_{ij}'s. This plot indicates that the samples have different means as well as variances and therefore different distributions. Since the distribution of the X_i's is most likely to look like the distribution of the Y_{ij}'s, we can assume that the X_i's too will not have an identical distribution. This should not surprise us in view of the fact that the timetable consists of three periods, namely night hours, off-peak hours and rush hours. It is very likely that the [illegible] during rush hours will have a distribution that is different from the distribution of the [illegible] during off-peak hours. The expected [illegible] will be highest during the rush hours. We conclude that our observations (and thus the differences) are not identically distributed, so that we cannot use the nonparametric tests for difference in location, such as the Wilcoxon signed rank test or the classical t-test in the case of normally distributed differences. Since we can view our data $(X_1, Y_1), \ldots, (X_{393}, Y_{393})$ as observations in a multisample repeated measurements design, an alternative could be a test for differences in location under a suitable multisample repeated measurements model. For this, however, we would need the variances of the (X_i, Y_i) to be the same for all i. In the next section we will explain how the problem of inequality of variances is handled.

A.3 Variance stabilizing transformation

Our idea is to find a transformation f that stabilizes the variance of all $f(Y_{ij})$'s. We write

$$U_i = f(X_i) \quad \text{and}$$
$$V_i = \frac{1}{n_i}\sum_{j=1}^{n_i} f(Y_{ij}) ,$$

for $i = 1, \ldots, 393$. Since the n_i are almost equal and

$$\mathrm{Var}(V_i) = \mathrm{Var}\Big(\frac{1}{n_i}\sum_{j=1}^{n_i} f(Y_{ij})\Big) = \frac{\mathrm{Var} f(Y_{i1})}{n_i} ,$$

we see that the variances of the V_i are also approximately equal. Moreover, we will see below that the variances of the U_i will be (approximately) stabilized too. This means that we can use multisample repeated measurements techniques can be applied to $(U_1, V_1), \ldots, (U_{393}, V_{393})$, as will be done in section A.4.

In order to find the desired transformation f, we first must know which distribution fits our observations best. In Figures 3a to 7a we see the exponential QQ plots of several sets of Y_{ij}'s, corresponding to a certain i. We see that these plots show a reasonably straight line. Figures 3b to 7b show the histograms together with the estimated exponential density functions. These histograms are representative of most of the examined histograms. The figures suggest that a transformation that stabilizes the variances of exponentially distributed variables may work. Since the distribution of the X_i was assumed to equal that of Y_{ij} except for a scaling factor, this transformation should also stabilize the variances of the transformed X_i's.

We now describe a method to determine a variance stabilizing transformation for exponentially distributed random variables (Scheffé, 1959).
Suppose $Y \sim \exp(\lambda)$, thus

$$\mathbb{E}(\bar{Y}) = \mu = \frac{1}{\lambda} \text{ a.s.}$$

$$\text{Var}(\bar{Y})^2 = \sigma_{\bar{Y}}^2 = (\frac{1}{\lambda})^2 = \frac{1}{\lambda^2}$$

We can write

$$\sigma_{\bar{Y}} = g(\mu) = \mu ,$$

with g the identity on $\mathbb{R}$. We recall that we seek a transformation f such that the standard deviation of $Z = f(\bar{Y})$ is equal, or at least approximately equal, to a predetermined constant σ_Z. Consider the first order Taylor expansion of f as a function of $\bar{y}$ in a small neighborhood of $\bar{y} = \mu$:

$$f(\bar{y}) = f(\mu) + f'(\mu)(\bar{y} - \mu) + R(\bar{y}, \mu) , \tag{A.2}$$

with $R(\bar{y}, \mu) \to 0$, as $\bar{y} \to \mu$. This gives

$$(z - f(\mu))^2 = f'(\mu)^2(\bar{y} - \mu)^2 + R^*(\bar{y}, \mu) , \tag{A.3}$$

with $R^*(\bar{y}, \mu) \to 0$, as $\bar{y} \to \mu$. Since approximately, for $\bar{y}$ close to μ,

$$\mathbb{E}(Z) = f(\mu) , \tag{A.4}$$

it follows from (A.3) that

$$\text{Var}(Z) = \mathbb{E}(Z - \mathbb{E}(Z))^2 = f'(\mu)^2 \text{Var}(\bar{Y}) + R^{**} ,$$

with $R^{**} \to 0$, as $\bar{y} \to \mu$. So we obtain for $\bar{y}$ close to μ the approximate result

$$\sigma_Z = f'(\mu)\sigma_{\bar{Y}} ,$$

or equivalently,

$$f'(\mu) = \frac{\sigma_Z}{\sigma_{\bar{Y}}} = \frac{\sigma_Z}{g(\mu)} .$$

Integrating this expression and switching notation yields

$$f(\bar{y}) = \sigma_Z \int \frac{1}{g(\bar{y})} d\bar{y} = \sigma_Z \int \frac{1}{\bar{y}} d\bar{y} = \sigma_Z \ln|\bar{y}| + C .$$

By taking $C = 0$ and $\sigma_Z = 1$, we finally obtain the transformation

$$f(x) = \log |x| .$$

Note that the above derivation does not depend on λ, so that f can be applied to the Y_{ij}'s as well as the X_i's. This transformation immediately imposes the restriction of nonzero observations. Since our observations do contain values that are zero, we replace each observation that is zero by the value 0.01. This modification is justified, since a value of 0.01 min. during 4 hours has the same interpretation as a real value of zero, which is no disruption at all. As we can see in figure 3, the variances of the samples of the transformed observations is quite stable.

Hypothesis (A.1) now becomes :

$$H_0^* : f(\mu_1) = f(\mu_2) = 0 ,$$

since

$$E(f(X)) = f(E(X)) = f(\mu_1) \text{ and}$$
$$E(T) = \frac{1}{n} n\, E(f(Y)) = f(\mu_2)$$

A.4 The I-sample repeated measurements design

In this section we will describe a suitable model for our transformed data. We start by grouping the pairs of observations $(U_1, V_1), \ldots, (U_{336}, V_{336})$, which were defined in the preceding section. Observations. The train frequency during 24 hours during the week days can be reflected as in figure A.1.

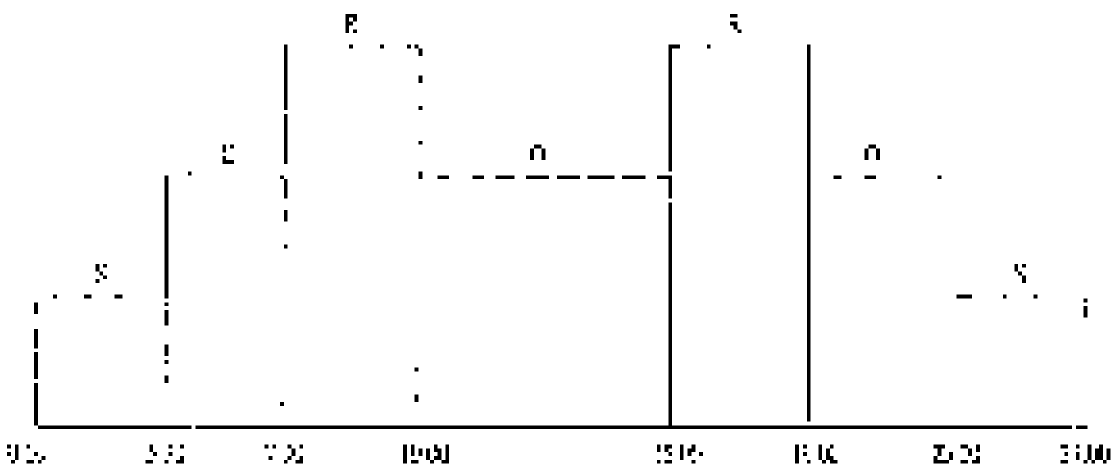


Figure A.1: Train frequency during 24 hours

There are three periods, namely night hours (N), off-peak hours (O) and rush hours (R). We characterize each group by period and also by district. Since we have 9 districts and 3 periods, we distinguish between 27 groups. However, the above scheme of the periods is not valid during the weekends. For every district we create an extra group, which contains all the observations of that district during the weekend. The total number of groups thus becomes 36. To analyse these grouped data, consider the I-sample repeated measurements model (Timm, 1975). The general formulation of such a model is the following. There are I samples. The ith sample has N_i objects, which are measured at p times. Defining

$$S_{ij} = (y_{ij1}, y_{ij2}, \ldots, y_{ijp}) \sim IN_p(\mu_i, \Sigma) , \; j = 1, \ldots, N_i; \; i = 1, \ldots, I ,$$

(the $\mathbf{I} \otimes \Sigma$ ...) indicates that the vectors are independent). The p-variate observation of the jth subject within the ith group is represented as

$$y_{ij} = \mu_i + e_{ij}, \quad j = 1, \ldots, N_i;\ i = 1, \ldots, I,$$

and $N = \sum_{i=1}^{I} N_i$ where $\mu_i = (\mu_{i1}, \mu_{i2}, \ldots, \mu_{ip})$ is a $1 \times p$ vector of means and e_{ij} is a vector of normally distributed random errors. This model can be written in the linear model form

$$Y = MB + E,$$

where Y is an $N \times p$ data matrix of the form

$$Y = \begin{pmatrix} y'_{11} \\ \vdots \\ y'_{1N_1} \\ \vdots \\ y'_{I1} \\ \vdots \\ y'_{IN_I} \end{pmatrix},$$

and B is the $I \times p$ parameter matrix

$$B = \begin{pmatrix} \mu_{11} & \mu_{12} & \cdots & \mu_{1p} \\ \mu_{21} & \mu_{22} & \cdots & \mu_{2p} \\ \vdots & \vdots & \vdots & \vdots \\ \mu_{I1} & \mu_{I2} & \cdots & \mu_{Ip} \end{pmatrix},$$

Here,

$$M = I_I \otimes 1_{N_i}, \quad \text{with } i = 1, 2, \ldots, I,$$

is the $N \times I$ design matrix with $\text{rank}(M) = r = I$. Here $\otimes$ denotes the Kronecker product and 1_{N_i} is a unity vector of length N_i. The data for the I-sample repeated measurements model can be arranged as in the following table :

	Measurements			
	1	2	...	p
Group 1	x_{111}	x_{112}	...	x_{11p}
	x_{121}	x_{122}	...	x_{12p}
	⋮	⋮	⋮	⋮
	x_{1N_11}	x_{1N_12}	...	x_{1N_1p}
⋮	⋮	⋮	⋮	⋮
Group i	x_{i11}	x_{i12}	...	x_{i1p}
	x_{i21}	x_{i22}	...	x_{i2p}
	⋮	⋮	⋮	⋮
	x_{iN_i1}	x_{iN_i2}	...	x_{iN_ip}
⋮	⋮	⋮	⋮	⋮
Group I	x_{I11}	x_{I12}	...	x_{I1p}
	x_{I21}	x_{I22}	...	x_{I2p}
	⋮	⋮	⋮	⋮
	x_{IN_I1}	x_{IN_I2}	...	x_{IN_Ip}

In our case we have $I = 30$ and $p = 2$. The two measurements per object are as follows:

measurement 1 = *SPAD*,
measurement 2 = *NO SPAD*

Each x_{ij1} is a Y_{ik} and x_{ij2} is the corresponding Y_{ik2} for a certain i_1 in {1, ..., 780}.

A.4.2 Testing hypotheses in the I-sample repeated measurements design

The hypotheses that we intend to test for the I sample data are:
H_{01} : Are there differences among measurements ?
H_{02} : Are there significant differences among groups ?

The hypothesis we are mainly interested in is H_{01}. The repeated measurements model has three assumptions with respect to the observation vectors X_{ij}:

1. The X_{ij}'s are independent.
2. The X_{ij}'s have a common variance-covariance matrix Σ.
3. The X_{ij}'s are normally distributed.

We have already seen that the first two assumptions are met.

In section A.3 we concluded that the observations themselves are probably not normally distributed. If we examine the transformed data, it appears that these most likely are also not normally distributed. So the third assumption is not satisfied. However, this will cause no problems for our analysis, since we are only interested in inferences about means. The reason for this is given by Box (1953). A transformation to achieve normality is therefore not necessary. Thus we may conclude that the I sample repeated measurements design is a reasonable [illegible] for the transformed [illegible] is the transformed [illegible] will use to test the hypotheses.

Substituting $I = 38$ and $p = $ [illegible], the above described hypotheses may be [illegible] in terms of the elements of the parameter matrix β :

$$H_{01} : \begin{pmatrix} \gamma_{11} \\ \gamma_{21} \\ \vdots \\ \gamma_{I1} \end{pmatrix} = \begin{pmatrix} \gamma_{12} \\ \gamma_{22} \\ \vdots \\ \gamma_{I2} \end{pmatrix},$$

$$H_{02} : \gamma_1 = \gamma_2 = \ldots = \gamma_I .$$

The hypotheses may also be represented as $H_0 : C\beta A = \Gamma$, where C, A and Γ have the following form for the different hypotheses :

H_{01} :

$$C = I_{38}, \quad A = \begin{pmatrix} \vdots \end{pmatrix}, \quad \Gamma = 0 ;$$

where rank(C)=38 and rank(A)=[illegible].

H_{02} :

$$C = (I_{[illegible]} \mid -1), \quad A = I_{[illegible]}, \quad \Gamma = 0 ,$$

where rank(C)=[illegible] and rank(A)=[illegible]

Defining

$$\begin{aligned} SS_e &= (YA - X\hat{\beta}A)'(YA - X\hat{\beta}A) \\ SS_t &= (YA - X\hat{\beta}_\omega A)'(YA - X\hat{\beta}_\omega A) , \\ SS_h &= SS_t - SS_e , \end{aligned}$$

where $\hat{\beta}$ is the least-square estimate in the large model Ω, and $\hat{\beta}_\omega$ is the estimate under the hypothesis $C\beta A = \Gamma$, we can now use the General Fundamental Least-Squares Theorem ([illegible], 1975). The proof of this theorem is included in appendix [illegible].

Theorem *Under the multivariate Gauss-Markoff setup,* $E(Y) = X\beta$ *and* $Var(Y) = (I_N \otimes \Sigma)$*, consider the* $q \times q$ *matrix* C *of rank* $q \leq r$ *such that each element of* $C\beta$ *is individually estimable. Let* A *be any* $p \times u$ *matrix of rank* $u \leq p \leq (N-r)$ *and* $Q = \min \mathrm{tr}(YA - X\beta A)'(YA - X\beta A)$*, subject to the condition* $C\beta A = \Gamma$*. Then*

1. $SS_e = A'Y'(I - M(M'M)^{-}M')YA$,
   $SS_h = (C\hat{\beta}A - \Gamma)'(C(M'M)^{-}C')^{-1}(C\hat{\beta}A - \Gamma)$.

2. $SS_e \sim W_q(N - r, A\Sigma A')$,
$SS_h \sim W_q(g, A\Sigma A', \Omega_h)$, where $\Omega_h = (CBA - \Gamma)'(C(X'X)^{-}C')^{-1}(CBA - \Gamma)$.
Furthermore, SS_e and SS_h are independent.

3. Under the null hypothesis H_0 : $CBA = \Gamma$

$$\Lambda = \frac{|SS_e|}{|SS_e + SS_h|} \sim U(q, \nu_h, \nu_e),$$

where $\nu_h = g$, $\nu_e = N - r$, $g = rank(C)$, 'Tr' denotes the trace of a matrix, $W_q(k, \Sigma, \Omega)$ represents the Wishart distribution of dimension q with parameters k, Σ, Ω and U is the distribution of a product of independent beta variables with parameters $(\nu_e - q + 1)/2$ and $\nu_h/2$.

The statistic Λ in the above theorem can be used to test the hypothesis H_0 : $CBA = \Gamma$. The multivariate analysis of variance table has the following form:

Source	SS	DF	MSS	E(MS)
Hypothesis	SS_h	g	SS_h/g	$A\Sigma A' + \Omega_h/g$
Residual	SS_e	$N - r$	$SS_e/(N - r)$	$A\Sigma A'$
Total	$SS_t = SS_h + SS_e$	$N - r + g$		

In strict accordance with the univariate analysis of variance, we would use the statistic $\frac{|SS_h|}{|SS_e|}$ to test the hypothesis. However, Wilks suggested the statistic $\Lambda = \frac{|SS_e|}{|SS_e+SS_h|}$, because it is more suitable on account of its tractability, and furthermore it is related to the likelihood ratio statistic. The statistic is known as Wilks Λ, and the test has the following form: Reject

$H_0 : CBA = \Gamma$

at a significance level α if

$$\Lambda = \frac{|SS_e|}{|SS_e + SS_h|} < U^{\alpha}(q, \nu_h, \nu_e),$$

where $U^{\alpha}(q, \nu_h, \nu_e)$ is the α-quantile of the distribution of U. In the special cases that SS_h and SS_e are 1×1 or 2×2, the test is equivalent to an F-test (see appendix C). The results are summarized in the following table.

Hypothesis	Λ	$\frac{1-\Lambda}{\Lambda}$	$\frac{1-\sqrt{\Lambda}}{\sqrt{\Lambda}}$	One tailed probability	Reject H_0 ($\alpha = 0.05$)
H_{01}	0.7725	0.2945		0.0065	YES
H_{02}	0.4703		0.4582	[illegible]	YES

Hypothesis H_{01} results in sum of squares matrices of dimension 1×1 and hypothesis H_{02} results in matrices of dimension 2×2. Hence, both hypotheses can be tested with an F-test.

see appendix C

In the above table we see that the hypotheses are rejected at a significance level of 5%. Rejection of H_{02} (differences among groups) is not surprising, since the groups were constructed by means of the district and period in which the SPAD occurred. We can expect differences between these groups, since the timetable depends on the period and the infrastructure depends on the location. The most interesting result, of course, is the rejection of the first hypothesis, the hypothesis for differences in measurements. So we may conclude the following:

The ucd preceding a SPAD (X) differ significantly from the ucd under 'normal' circumstances (Y).

Note that the hypothesis would still be rejected at a significance level of 1%. In table 8 the differences $\delta_i = \bar{x}_i - \bar{y}_i$ are summarized, $i = 1, \ldots, 36$. From this table we may conclude that a SPAD is preceded by a significant increase of the ucd.

i	δ_i	i	δ_i
1	1.9537	19	-0.1452
2	-0.4711	20	1.1172
3	1.4625	21	1.8032
4	0.5655	22	0.1784
5	1.9625	23	0.0415
6	1.1437	24	1.2375
7	1.2963	25	0.9072
8	-0.1775	26	0.2470
9	1.2422	27	1.3760
10	2.1724	28	-0.2306
11	-2.3698	29	1.4417
12	2.5172	30	1.9814
13	-0.9907	31	0.7657
14	-0.3755	32	1.7602
15	1.5409	33	3.2537
16	0.4154	34	0.9275
17	0.2739	35	0.0054
18	-0.1412	36	0.3758

Table 8

A.5 Modelling the ucd

A.5.1 Choice of the model

In the preceding section we have seen that a SPAD is preceded by a significant increase of the ucd. In this section we will try to investigate which factors influence the ucd. We start by determining the total ucd that is registered per month in the years 1991 until 1993. Next we determine the total number of registrations of the nine irregularities mentioned in chapter 3 (also per month and in the same years). Here we take all 3 districts together. This merging of districts is justified, since we are now interested in the irregularities that lead to a high degree of company disruption in a certain month. We have now created variables of length 36, one entry for each month. We recall that the selected irregularities are:

- Absent personnel ("abspers")
- Communication disturbance/disagreement between personnel ("commpers")
- Rush due to passengers ("rushpass")
- Irregularities with/due to preparation of the train ("irrprep")
- Late platforming ("lateplat")
- Malfunctions of signals ("signal")
- Malfunctions of switches ("switch")
- Work not finished in time ("worknfin")
- Malfunctions of rolling stock ("rollstock")

The abbreviations that will be used below are indicated in parenthesis. In order to gain a first impression of any correlations, we examine the scatterplots of ncd and the different irregularities (figures 9 to 18). There seems to be a linear relationship in the plots of abspers, commpers, irrprep and delays. The plot of lateplat also shows a somewhat linear relationship. The bivariate linear correlation coefficients are given in the following table:

	Corr. coeff. with ncd
abspers	0.8279
commpers	0.8458
rushpass	0.4407
irrprep	0.7354
lateplat	0.6424
signal	0.1563
switch	0.2212
worknfin	0.3440
rollstock	0.3775

We see that abspers, commpers, irrprep and lateplat have the largest correlation coefficient with ncd. Since the scatterplots and the values of the correlation coefficients indicate a linear relationship between some irregularities and the ncd, the linear regression model is a good choice to model the ncd. For convenience we introduce a shorter notation for the variables. We will denote the total ncd by $Y_1, \ldots, Y_{36}$ and the irregularities by $x_{1,1}, \ldots, x_{1,36}, \ldots, x_{9,1}, \ldots, x_{9,36}$. Note that Y_i in this section is not the same as Y_i in section A.1. The multiple linear regression model for our 36 observations and 9 independent variables then has the following form:

$$
\begin{aligned}
Y_i &= \beta_0 + \beta_1 x_{1i} + \cdots + \beta_9 x_{9i} + e_i \\
Ee_i &= 0 \\
Ee_ie_j &= \begin{cases} \sigma^2, & \text{if } i = j \\ 0, & \text{if } i \neq j \end{cases}
\end{aligned}
$$

for $i = 1, \ldots, 36$. Here Y_i is the ith observation; x_{ij} is the corresponding known value of the jth independent variable; $\beta_0, \beta_1, \ldots, \beta_{10}$ are unknown constants and ϵ_i is the stochastic error in the ith observation. The matrix X with first column equal to $(1, \ldots, 1)^t$ and jth column equal to $(x_{j1}, \ldots, x_{j36})^t$ is assumed to be of full rank, rank(X)=11.

A.5.2 Selection of the explanatory variables

In this section we determine which variables should be included in the model. If we examine the scatterplots (figures 8 to 16) and the correlation coefficients, we see that [illegible] has the strongest linear relationship with the variable sleepers. So this variable will be the first to be included in the model. Next we examine the models with two variables, with the first variable taken to be [illegible]. The results are summarised in the following table:

2^{nd} variable	R^2	RSS	s	β([illegible], ..., intercept)	$\sigma(\beta)$
1. [illegible]	0.?18	[illegible]	455.59	(1?.3?, 6.50, 1?2?.??)	(2.92, 1?.80, 3?6.3?)
2. [illegible]	0.?42	[illegible]	461.??	(12.48, ?.14, 1824.67)	(2.0?, 3.95, 3?9.7?)
3. [illegible]	0.678	5966969.7	42?.6?	(8.5?, 6.18, 22?.63)	(2.5?, 2.41, 197.21)
4. laneplat	0.6?9	628?067.2	4?5.67	(12.25, 11.06, 1?62.5?)	(2.?6, 6.37, 2?7.43)
5. railstock	0.683	5?4?84?.0	441.39	(?.26, 0.96, ?21?.24)	(2.?4, 0.73, ?39.5?)
6. signal	0.617	6675292.9	456.45	(12.90, 1.40, 1?1?.25)	(1.64, 5.5?, 4??.4?)
7. workfin	0.790	?298546.6	400.27	(12.46, 27.62, 1463.12)	(1.70, ?.??, 342.15)
8. switch	0.651	6077545.3	459.22	(14.2?, 13.33, 1?25.53)	(1.81, 2.06, 454.0?)

Model 7 which also includes the variable workfin gives the best results. This model has the highest coefficient of determination, the lowest value of RSS and the lowest estimate of σ. In order to determine whether we should include more variables, we apply the partial F-test. This test is used to test the hypothesis

$$H_0 : \beta_{q+1} = \ldots = \beta_p = 0, \ \beta_0, \beta_1, \ldots, \beta_q \text{ arbitrary};$$
$$H_1 : \beta_j \neq 0, \text{ for some } j, \ q+1 \leq j \leq p; \ \beta_0, \beta_1, \ldots, \beta_q \text{ arbitrary}.$$

The test statistic is

$$F^* = \frac{(n-q-1)(RSS_q - RSS_p)}{(p-q)RSS_q}.$$

If the null hypothesis is true, F^{PV} has an F-distribution with $(q-p)$ and $(n-q-1)$ degrees of freedom, provided the errors are independent and normally distributed (see section A.5.4). The null hypothesis is rejected at a significance level α if $F^{PV} \geq F_{(q-p,\, n-q-1;\, 1-\alpha)}$. Application of the test with $p = 2$, $q = 3$ and $n = 36$ yields the following:

$$RSS_p = 4388246.[illegible]$$

$$RSS_q = 2591[illegible].952$$

$$F^{PV} = \frac{32 \times 2727265.70}{1 \times 3804090.952} = 0.959 > 2.328 = F_{[illegible]}$$

Hence the null hypothesis is rejected at a significance level $\alpha = 0.05$, and therefore we should include more variables in the regression model. The models with three variables, with alegeern and workTie already included, are summarized in the following table:

Extra variable	R^2	RSS	σ	$\hat{\beta}$(alegeern, workTie, ..., extra var)	$s(\hat{\beta})$
1. carriages	0.716	5252[illegible]	410.[illegible]	(13.63, 27.48, -0.65, 1405.24)	(3.57, 9.20, 14.08, 459.27)
2. coaches	0.735	4875813.1	390.47	(11.88, 27.24, 3.39, 1340.05)	(1.86, 8.77, 2.97, 324.24)
3. freqsep	0.735	4871724.5	382.21	(9.00, 24.72, 6.81, 1503.15)	(2.52, 6.87, 0.12, 523.70)
4. lateplus	0.724	4944846.6	393.10	(11.90, 25.07, 6.35, 1270.31)	(1.87, 8.86, 5.67, 336.57)
5. railstock	0.755	4324162.[illegible]	367.9[illegible]	(12.97, 33.54, 1.78, 573.47)	(1.66, 8.71, 0.84, 519.46)
6. signal	0.701	5361[illegible]20.3	409.31	(13.25, 27.05, 0.14, 1981.86)	(1.75, 9.25, 3.36, 420.49)
7. switch	0.72[illegible]	498[illegible]15.6	394.42	(13.71, 24.16, 8.22, 1098.04)	(1.67, 9.10, 5.57, 402.57)

Model 5, which includes the variable railstock, gives the best results. This model has the highest coefficient of determination and the lowest values for σ and RSS. So the variable railstock is also added to our model. Application of the partial F-test with $p = 3$, $q = 4$ and $n = 36$ gives the following:

$$RSS_p = 4032195.154$$

$$RSS_q = 2795690.562$$

$$F^{PV} = \frac{31 \times 1728375.10}{1 \times 2575690.5[illegible]} = 2.8[illegible] > 2.474 = F_{[illegible]}$$

Thus the null hypothesis is again rejected at a significance level $\alpha = 0.05$, and therefore we should include more variables in the regression model. We examine the models with four variables :

# variable	R^2	RSS	σ	β(sleepers, worklin, milestock, ..., intercept)
1. crossings	0.763	4123000.2	378.47	(12.36, 33.25, 1.79, -6.49, 370.64)
2. rushpass	0.837	3004775.3	311.33	(8.95, 36.38, 2.34, 2.32, -38.20)
3. bridges	0.253	5139462.2	315.15	(2.04, 33.22, 2.29, 3.11, 640.17)
4. interlins	0.763	4160256.7	366.34	(11.23, 33.64, 1.57, 4.66, 384.05)
5. signal	0.731	4253822.3	372.33	(11.88, 35.74, 1.72, 2.78, 267.37)
6. switch	0.782	4271045.7	371.36	(12.26, 33.25, 1.9[illegible], 0.45, 267.28)

$s(\hat\beta)$
(2.46, 3.75, 0.05, 18.05, 587.18)
(1.55, 7.45, 0.56, 2.60, 440.98)
(2.33, 7.36, 0.33, 2.65, 454.00)
(1.77, 8.91, 0.85, 5.43, 534.78)
(2.67, 8.23, 0.33, 5.42, 572.32)
(1.79, 8.46, 0.71, 5.77, 515.65)

Model 2 gives the best improvements. Application of the partial F-test with $p = 4$, $q = 5$ and $n = 32$ gives the following results :

$$RSS_p = 3004775.259$$
$$RSS_q = 3595530.462$$

$$F^{**} = \frac{26 \times 409764.79}{1 \times 223550.95} = 0.920 < 4.267 = F_{[illegible]}$$

This time the H_0 hypothesis is not rejected at a significance level $\alpha = 0.05$, so there is no reason to include more variables in our model. The regression model now contains the variables sleepers, worklin, milestock and rushpass.

A.5.3 Collinearity

Examining the estimates of the regression coefficients and the standard deviations of their estimators, we see that only the estimator of the intercept has a somewhat disturbing standard error. A possible explanation for this is the presence of collinearity. To investigate this aspect, we first examine the bivariate correlation coefficients for all possible combinations of the independent variables :

rushpass and worklin	0.0335
rushpass and milestock	-0.1507
rushpass and sleepers	0.4652
worklin and milestock	-0.2794
worklin and sleepers	0.1022
milestock and sleepers	0.2738

The correlation coefficient of rushpass and sleepers looks a little disturbing, but examination of the scatterplots (figures 17 to 22) demonstrates that this correlation is probably not [illegible] is very small. The variance inflation factors are given in the following table

workkm	1.157
railpass	1.460
sleepers	1.673
railstock	1.378

These values give no indication of the presence of any collinearity. Finally we examine the variance decomposition:

Eigenvalue	Cond. Index	Intercept	Workkm	Railpass	Sleepers	Railstock
1. 4.258	1.000	0.0003	0.0062	0.0089	0.0010	0.0007
2. 0.250	4.178	0.0014	0.1255	0.6687	0.0000	0.002
3. 0.159	5.162	0.0006	0.0529	0.0600	0.0584	0.0305
4. 0.021	14.272	0.1271	0.0032	0.2052	0.2295	0.0012
5. 0.008	24.193	0.8547	0.8104	0.1167	0.7609	0.9254

The intercept and railstock are collinear according to the fifth row. This explains the somewhat disturbing standard error of the estimate of the intercept. If we do not include an intercept in the regression model, we obtain the following results:

$$R^2 = 0.6876$$
$$s = 303.14$$
$$RSS = 3034954.43$$

Variable	$\hat{\beta}$	$s(\hat{\beta})$	95% confidence interval for β
1. sleepers	8.65	1.22	[5.37 ; 11.95]
2. railpass	6.32	2.45	[2.31 ; 10.35]
3. workkm	29.24	1.56	[25.38 ; 32.58]
4. railstock	2.55	0.26	[1.95 ; 3.22]

This table shows that there is hardly any change in the results. The coefficient of determination, R^2, the estimates and the standard errors of the estimates remain practically the same. So it makes no difference whether we include the intercept or not. Since including the intercept results in an estimate with a somewhat disturbing standard error, it is therefore better not to add the intercept in our model. In the following sections we will proceed with the model without the intercept, given in the above table.

A.5.4 Outliers and influence points

In this section we investigate which observations have an extreme value. The first step is to examine a number of plots.

1. Plot of response (aov) with the independent variables (figures 8, 10, 13 and 15).
   The plot of railpass shows that observations 19 and 20 are suspicious. The plot of sleepers suggests that observations 33, 34 and 35 are extreme. In the plot of railstock we notice observation 2.

2. Plot of the residuals with the independent variables (figures 23 to 26).
   Again the plot of the space shows that observations 19 and 20 are conspicuous, and in the rollstock plot we again notice observation 2.

3. Plot of the residuals with the predicted value (figure 27).
   Observations 3, 5, 15, 21, 22 and 23 look suspicious.

4. QQ plot of the residuals (figure 28).
   This plot shows no particularly points.

5. Plot of the predicted value with the independent variables (figures 28 to 31).
   These plots give the same results as in 2.

In order to determine which of the suspicious observations are outliers, we use the *test for outliers*. The ith observation is called an outlier, if for some $\delta \neq 0$

$$Y_j = \begin{cases} x_j^t\beta + \epsilon_j & \text{for } j \neq i, \\ x_j^t\beta + \delta + \epsilon_j & \text{for } j = i. \end{cases}$$

This model is called the *mean shift outlier model*. By testing the hypothesis $H : \delta = 0$ we can test if the ith observation is an outlier. Next, define an n-vector u with $u_j = 0$ for $j \neq i$ and $u_i = 1$. We then fit a linear regression model of the form

$$Y = X\beta + u\delta + \epsilon ,$$

and we test the hypotheses

$$\begin{aligned} H_0 &: \delta = 0, \beta \text{ arbitrary}, \\ H &: \delta \neq 0, \beta \text{ arbitrary} \end{aligned}$$

with the following test :

Reject H_0 at a significance level α if

$$|t_{n-1}| = \frac{\hat{\delta}}{\sqrt{\mathrm{cov}(\hat{\beta},\hat{\delta})_{p+1,p+1}}} \geq t_{n-p-2;\alpha/2} ,$$

where $\mathrm{cov}(\hat{\beta},\hat{\delta}) = \hat{\sigma}_u^2(X_u^tX_u)^{-1}$ with X_u an $n \times (p+1)$ matrix (X, u), and

$$\hat{\sigma}_u^2 = \frac{RSS_u}{(n-p-1)} = \frac{(Y - X\hat{\beta} - u\hat{\delta})^t(Y - X\hat{\beta} - u\hat{\delta})}{(n-p-1)}$$

With $\alpha = 0.05$ and $t_{n-p-2;\alpha/2} = t_{19;0.025} = 2.093$ we find the following results :

Observation	t-test statistic	Reject H_0
2	0.175	no
3	2.2[illegible]	yes
5	0.306	no
19	1.324	no
20	2.533	yes
21	0.260	no
22	1.475	no
23	0.297	no
25	1.747	no
34	2.2[illegible]	yes
35	0.299	no

We see that observations 3, 20 and 34 are outliers. To detect influence points, we examine the Cook's distances. The highest values are found with observations 19, 20 and 33, which are 0.2421, 0.3[illegible] and [illegible] respectively. However, these values do not indicate that the observations are influence points. Leverage points can be detected by means of the potentials. Observations 2 and 19 have the highest values, of 0.2765 and 0.3583 respectively. Again, these values do not suggest the presence of any Leverage points.

So the only points that are suspicious are the observations 3, 20 and 34. To see how these points influence the regression, we fit the model without these three observations. The results are as follows:

$$R^2 = 0.8789$$
$$RSS = 1920886.25$$
$$s = 258.37$$

Variable	$\hat{\beta}$	$\sigma(\hat{\beta})$	95 % confidence interval for β
sleepers	8.55	1.41	[5.73 ; 11.37]
subbase	10.42	2.33	[5.48 ; 15.06]
[illegible]	35.52	5.96	[23.35 ; 47.69]
railtrack	2.51	0.29	[1.97 ; 3.07]

The results are slightly better, but not much. Since there is also no indication that the observations 3, 20 and 34 are measurement errors, there is no reason to omit these points from the analysis.

A.3.5 Examination of the residuals

The regression model makes two assumptions about the measurement errors, namely independence and normally distributed with mean zero and common variance σ^2. In this section we will use the residuals to check for violation of these assumptions.

To test for first order autocorrelations, we can use the Durbin-Watson test. The test statistic is defined as

$$d = \frac{\sum_{i=2}^{n}(e_i - e_{i-1})^2}{\sum_{i=1}^{n} e_i^2} .$$

The hypotheses are

$$\begin{aligned} H_0 &: \rho = 0 , \\ H_1 &: \rho \neq 0 \end{aligned}$$

where ρ is the first order population autocorrelation coefficient. The test becomes:

if $d < d_L$ then H_0 is rejected : positive autocorrelation,
if $d > 4 - d_L$ then H_0 is rejected : negative autocorrelation,
if $d_U < d < 4 - d_U$ then H_0 is not rejected,
if $d_L < d < d_U$ or $4 - d_U < d < 4 - d_L$ then there is no conclusion.

The appropriate values of d_L and d_U can be found in tables (Greene, 1993). We find $d = 1.3607$, $d_L = 1.286$ and $d_U = 1.734$. Unfortunately, the Durbin-Watson test gives us no conclusion. However, the partial autocorrelogram of the residuals (figure 78) indicates that there are no severe autocorrelations.

To gain a first impression of the distribution of the residuals, we observe the QQ-plot and histogram (figures 81 and 82). These plots do not question the normality assumption. The next step is to perform formal tests for normality, such as the *Shapiro-Wilk* and *Kolmogorov-Smirnov-Lilliefors* test. However, we know that the residuals are neither independent nor identically distributed, since

$$\begin{aligned} e &= Y - \hat{Y} \\ &= (I - V)Y \\ &= (I - V)(X\beta + \epsilon) \\ &= X\beta - VX\beta + (I - V)\epsilon \\ &= (I - V)\epsilon , \end{aligned}$$

with $V = X(X'X)^{-1}X'$, and thus

$$\begin{aligned} \mathrm{Var}(e) &= \sigma^2(I - V)(I - V)' \\ &= \sigma^2(I - V), \quad \text{since } V \text{ is symmetric and idempotent.} \end{aligned}$$

So the variance of e_i depends on σ^2 and v_{ii}. In order to use the above-mentioned tests, we look at the transformed residuals (Cook and Weisberg, 1982).

Let C be an $n \times (n - p')$ matrix (p' = number of independent variables). Let $\hat{e}$ be defined as

$$\hat{e} = C'Y .$$

The vector $\hat{e}$ is called a vector of linear unbiased scalar residuals if

$$\begin{aligned} E(\hat{e}) &= 0 \quad \text{(unbiasedness condition)}, \\ \mathrm{Var}(\hat{e}) &= \sigma^2 I \quad \text{(scalar covariance matrix condition).} \end{aligned}$$

For these conditions to hold it is sufficient that

$$C^T X = 0 \qquad \text{(A.5)}$$
$$C^T C = I \qquad \text{(A.6)}$$

A common method of choosing C requires that p' cases are constrained to have zero residuals. The choice of these cases may be arbitrary, so that the definition of the uncorrelated residuals is not unique. Suppose we partition

$$e^T = (e_1^T \;\; e_2^T), \quad X^T = (X_1^T \;\; X_2^T) \quad \text{and} \quad C^T = (C_1^T \;\; C_2^T),$$

such that the subscript 1 corresponds to the p' cases constrained to have zero residuals, and subscript 2 corresponds to the remaining $n - p'$ cases. We assume X_1 to be nonsingular. From B.4 (appendix B) and A.6 it follows that C_2 must satisfy

$$I = C_2^T [I - X_2 (X^T X)^{-1} X_2^T]^{-1} C_2 .$$

C_2 is solved by means of the singular value decomposition. Write

$$A = I - X_2 (X^T X)^{-1} X_2^T .$$

Then, since A is symmetric

$$A = UDV^T = UDU^T ,$$

where U and V are unitary matrices and D is a diagonal matrix with diagonal elements equal to the nonnegative singular values of A. Thus

$$A^{-1} = (U^T)^{-1} D^{-1} U^{-1} .$$

If we define

$$C_2 = U D^{\frac{1}{2}} ,$$

we have

$$\begin{aligned} C_2^T A^{-1} C_2 &= D^{\frac{1}{2}} U^T (U^T)^{-1} D^{-1} U^{-1} U D^{\frac{1}{2}} \\ &= D^{\frac{1}{2}} D^{-1} D^{\frac{1}{2}} \\ &= I \end{aligned}$$

C_1 can be determined uniquely with A.5:

$$\begin{aligned} & (C_1^T \;\; C_2^T) \begin{pmatrix} X_1 \\ X_2 \end{pmatrix} = 0 \\ \Leftrightarrow \;& C_1^T X_1 + C_2^T X_2 = 0 \\ \Leftrightarrow \;& C_1^T = -C_2^T X_2 X_1^{-1} . \end{aligned}$$

The tests for normality can then be applied to the transformed residuals. The results are summarized in the following table :

	Statistic	Significance
Shapiro Wilks	0.9895	0.3677
Kolm.-Sm. (Lilliefors)	0.0470	> 0.2000

In both cases the null hypothesis of normality is not rejected at a significance level $\alpha = 0.05$. In figures 36 and 37 we see the histogram and QQ-plot of the transformed residuals. These plots strongly suggest a normal distribution.

So we may conclude that $\tilde{\varepsilon}$ has a multivariate normal distribution. Therefore, the original residuals are normally distributed too, since each linear combination of the ε_i's corresponds to a linear combination of the $\tilde{\varepsilon}_i$'s. Indeed, we have

$$
\begin{aligned}
\tilde{\varepsilon} &= C'Y \\
&= C'X\beta + C'\varepsilon \\
&= C'\varepsilon .
\end{aligned}
$$

Let $a \in \mathbb{R}^{n-p}$ be a real valued vector, and write $C = (c_{ij})$. Then

$$
\begin{aligned}
a'\tilde{\varepsilon} &= a'C'\varepsilon = (a_1, \ldots, a_{n-p}) \begin{pmatrix} \sum_{j=1}^{n} c_{j1}\varepsilon_j \\ \vdots \\ \sum_{j=1}^{n} c_{j(n-p)}\varepsilon_j \end{pmatrix} \\
&= \sum_{j=1}^{n} (a_1 c_{j1} + a_2 c_{j2} + \ldots + a_{n-p} c_{j(n-p)})\varepsilon_j .
\end{aligned}
$$

Finally, we examine some plots of the original residuals in order to check for violation of the assumption of constant variance of the errors, and whether higher order terms of the present variables should be included in the model.

1. Plots of the residuals with the independent variables (figures 38 to 35).
   These plots do not show any systematic relationship in the dispersion of the points.

2. Plots of the residuals with the variables not included in the model (figures 36 to 42).
   These plots do not reveal any relationships.

3. Plot of the residuals with the response (figure 43).
   This plot shows no increase or decrease of the dispersion of the points.

The plots do not suggest that extra variables or higher order terms of the present variables should be included in the model. Nor is there any indication that the assumption of equal variance of the errors is violated.

A.5.6 Goodness of fit of the model

The regression model derived in the preceding sections can be evaluated by means of a number of criteria. The first criterion is the coefficient of determination which gives us an overall impression of the performance of the model. For our regression model we find the value 0.8325, which is sufficiently close to 1. Furthermore, the estimated standard errors of the estimates of the regression coefficients and the least squares estimate of σ^2 are not disturbingly large. As we would expect, the regression coefficients have positive signs. This means that if the number of registrations of the different irregularities increases, then so does the cost.

Another important aspect is that the model assumptions are met. In the preceding section we have seen that it is reasonable to assume that the errors are

1. independent and
2. normally distributed with constant variance.

A final impression of the goodness of fit of the model is given by figure 44. Here, the observed value of the response is plotted against the predicted value of the response. The plot shows a clear linear relationship. Considering all these criteria, we may conclude that the regression model without intercept given in section A.5.3 provides a very good description of the data.

A.5.7 The effect of the independent variables

In this section we will determine which independent variables in the regression model have the greatest effect on the cost. We have the following model:

$$E[\text{cost}] = 8.01 \times \text{sleepers} + 9.82 \times \text{turnouts} + 2.62 \times \text{rollstock} + 39.24 \times \text{worklin} ,$$

where all variables are totals per month. We write the equation as

$$y = \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 ,$$

where y is the expected cost per month and $x_i = (x_{i1}, \ldots, x_{i4})^T$ is the ith explanatory variable, with

x_1 = sleepers
x_2 = turnouts
x_3 = rollstock
x_4 = worklin.

Suppose that variable x_1 is reduced by δ percent. Then the expected total cost in month i becomes

$$\begin{aligned} y_i^{new} &= \beta_1 x_{i1}\left(1 - \frac{\delta}{100}\right) + \beta_2 x_{i2} + \beta_3 x_{i3} + \beta_4 x_{i4} \\ &= \beta_1 x_{i1} + \beta_2 x_{i2} + \beta_3 x_{i3} + \beta_4 x_{i4} - \beta_1 x_{i1} \frac{\delta}{100} \\ &= y_i^{old} - \beta_1 x_{i1} \frac{\delta}{100} . \end{aligned}$$

Hence, the total expected ucd in month i decreases by $\beta_1 x_{1i} \frac{f}{100}$. In percentage terms the decrease is

$$\frac{\beta_1 x_{1i} f}{y_i^{obs}} \times 100\% = f \frac{\beta_1 x_{1i}}{y_i^{obs}} \times 100\% = f_1 f \times 100\% ,$$

where

$$f_1 = \frac{1}{n} \sum_{i=1}^{n} \frac{\beta_1 x_{1i}}{y_i^{obs}} .$$

Thus the effect of a decrease of the variable x_1 on y^{obs} is proportional to the contribution of x_1 to y^{obs}. This conclusion is valid for all four independent variables in the equation. So for a given decrease of f percent of x_1, x_2, x_3 or x_4, we can compute the decrease of the expected ucd in percentage terms by means of the fractions f_1, f_2, f_3 and f_4. With our data we find the following fractions :

$$\begin{aligned} f_1 &= 0.37 \\ f_2 &= 0.78 \\ f_3 &= 0.42 \\ f_4 &= 0.14 \end{aligned}$$

So a decrease of x_1 and x_2, corresponding to absent personnel and malfunctions of rolling stock, will have the greatest effect on the ucd.

A.5.8 Again: The reliability of the data

In chapter 3 we have seen that the registrations made by NS in general lead to lower values of the number of delays than those observed by BOVER. In this section we show that an overall relative increase of our response data does not affect our results. Suppose the response values are

$$Y_{new} = \alpha Y ,$$

where $\alpha > 1$ and Y represents the values computed from the registrations. The hypotheses tested in section A.4.1 could all be written in the form $H : C\beta A = D$, where $D = 0$ in all three cases. So we have

$$\begin{aligned} SS_e^{new} &= A' Y_{new}' [I - X(X'X)^{-1} X'] Y_{new} A = \alpha^2 SS_e \\ SS_h^{new} &= [C(X'X)^{-1} X' Y_{new} A]' [C(X'X)^{-1} C']^{-1} [C(X'X)^{-1} X' Y_{new} A] \\ &= \alpha^2 SS_h . \end{aligned}$$

Hence

$$\Lambda^{new} = \frac{|SS_e^{new}|}{|SS_e^{new} + SS_h^{new}|} = \frac{\alpha^2 |SS_e|}{\alpha^2 |SS_e + SS_h|} = \Lambda .$$

So a multiplication of the Y matrix with a scalar will have no effect on Wilks Λ criterion for the hypotheses tested in section A.4.1, and therefore our conclusion will remain the same. In particular, the conclusion of significant differences in frequencies is still valid. Obviously, multiplication of the Y vector and X matrix in the regression model from section A.5.1 with a scalar α (> 1) will also have no effect on the results.

Appendix B

Some results from matrix algebra

In this appendix we will give some results[1] of matrix algebra that will be mainly used to prove the general formulae of least-squares theorem in appendix D. In the following 'tr' denotes the trace of a matrix.

THEOREM B.1 Let $A = p \times q$, $B = q \times r$ and $C = r \times p$ be matrices, then

$$\mathrm{tr}(ABC) = \mathrm{tr}(CAB) = \mathrm{tr}(BCA).$$

THEOREM B.2 Let A be a symmetric matrix, then

A is idempotent $\Leftrightarrow$ all eigenvalues of A equal 0 or 1.

THEOREM B.3 Let X be a real valued $p \times q$ matrix and G a generalized inverse of $X'X$,

then

i. G' is also a generalized inverse of $X'X$.

ii. $XGX'X = X$ and $X'XGX' = X'$.

iii. XGX' is invariant if G is chosen to be different generalized inverse of $X'X$.

iv. XGX' is symmetric (whether G is or not).

THEOREM B.4 (*Updating formula*[2]) Let A be a $p \times p$ rank p symmetric matrix and suppose that a and b are $q \times p$ rank q matrices. Then

$$(A + a'b)^{-1} = A^{-1} - A^{-1}a'(I_q + bA^{-1}a')^{-1}bA^{-1},$$

provided that the inverses exist. This formula shows how to modify the inverse of the symmetric non-singular matrix $X'X$ when one or more rows of a matrix are deleted or added. The most important special case is that of deleting a single row x_i' from X. Setting $A = X'X$, $a = -x_i'$, $b = x_i'$ and representing $X_{(i)}$ as the matrix X with the ith row deleted, we have

$$(X_{(i)}'X_{(i)})^{-1} = (X'X - x_i x_i')^{-1} = (X'X)^{-1} + \frac{(X'X)^{-1}x_i x_i'(X'X)^{-1}}{1 - x_i'(X'X)^{-1}x_i}$$

[1] See [illegible], [illegible]
[2] See Cook and Weisberg, 1982

Suppose f is a function of mn variables $x_{11}, x_{12}, \ldots, x_{mn}$ represented by the matrix

$$X = \begin{pmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{pmatrix},$$

so that $y = f(X)$, then the partial derivative of a function f with respect to the matrix X is defined by the $m \times n$ matrix

$$\frac{\partial f}{\partial X} = \left[\frac{\partial f}{\partial x_{ij}}\right].$$

This definition is applied as follows. If X is an $m \times n$ matrix and A is a matrix of constants, then

1. $\frac{\partial}{\partial X}[\mathrm{Tr}(X)] = \frac{\partial}{\partial X}[\mathrm{Tr}(X^T)] = I_n$.
2. $\frac{\partial}{\partial X}[\mathrm{Tr}(AX)] = \frac{\partial}{\partial X}[\mathrm{Tr}(XA)] = A^T$.
3. $\frac{\partial}{\partial X^T}[\mathrm{Tr}(AX)] = \frac{\partial}{\partial X^T}[\mathrm{Tr}(XA)] = A$.
4. $\frac{\partial}{\partial X}[\mathrm{Tr}(X^T AX)] = (A + A^T)X$.
5. $\frac{\partial}{\partial X}[\mathrm{Tr}(X^T AX)] = X^T(A^T + A)$.
6. If A is symmetric, then

$$\frac{\partial}{\partial X}\mathrm{Tr}(X^T AX) = 2AX.$$

Appendix C

The $N_{m,r}$ and Wishart distribution

In this appendix we will formally define the matrix normal and Wishart distributions and give some properties of these distributions (Arnold, 1981).

Let $Z = (z_{ij})$ be an $n \times p$ stochastic matrix where the z_{ij} are independent and distributed as

$$z_{ij} \sim N(0,1).$$

The moment generating function M_Z of Z thus equals the product of the moment generating functions of the z_{ij}:

$$M_Z(t) = \prod_{i,j} e^{\frac{1}{2} t_{ij}^2} = e^{\frac{1}{2} \sum_i \sum_j t_{ij}^2} = e^{\frac{1}{2} \mathrm{tr}(tt')},$$

where $t = (t_{ij})$ is an $n \times p$ matrix. Let A, B and μ be matrices of dimensions $m \times n$, $p \times r$ and $m \times r$ respectively.
Define

$$Y = AZB + \mu.$$

Next we will use the property

If $Y = AXB + C$, then

$$M_Y(t) = e^{\mathrm{tr}(C't)} M_X(A'tB')$$

and find together with theorem B.1 (appendix B)

$$M_Y(t) = e^{\mathrm{tr}(\mu't) + \frac{1}{2} \mathrm{tr}(A'tB'Bt'A)}.$$

Let $\Sigma = AA'$ and $\Gamma = B'B$, then

$$M_Y(t) = e^{\mathrm{tr}(\mu't) + \frac{1}{2} \mathrm{tr}(\Sigma t \Gamma t')} \qquad \text{(C.1)}$$

Note that Ξ and Σ are nonnegative definite matrices.

Definition : Let μ be an $n \times p$ matrix, Ξ and Σ be $n \times n$ and $p \times p$ nonnegative definite matrices. We say that Y has a *matrix normal distribution* with parameters μ, Ξ and Σ if Y is an $n \times p$ random matrix having moment generating function given by B.1. We write

$$Y \sim N_{n,p}(\mu, \Xi, \Sigma)$$

The means, variances and covariances of Y are given by the following theorem :

THEOREM C.1 If $Y \sim N_{n,p}(\mu, \Xi, \Sigma)$ then

1. $E(Y_{ij}) = \mu_{ij}$.
2. $Var(Y_{ij}) = \Xi_{ii}\Sigma_{jj}$;
3. $Cov(Y_{ij}, Y_{i'j'}) = \Xi_{ii'}\Sigma_{jj'}$

For a proof of this theorem the reader is referred to Arnold (1981). We now define the Wishart distribution. This distribution can be thought of as a generalized χ^2 distribution. Let

$$X = \begin{pmatrix} X_1' \\ \vdots \\ X_n' \end{pmatrix} \sim N_{n,p}(\mu, I, \Sigma)$$

(i.e., the X_i are independent , $X_i' \sim N_p(\mu_i', \Sigma)$).
Let

$$W = X'X = \sum_{i=1}^{n} X_i X_i' \, .$$

Then W is said to have a *Wishart distribution*. Note that W is a $p \times p$ nonnegative definite matrix and . It can be shown that the distribution of W depends on μ only through $\mu'\mu$. We say that the distribution of W is a *p-dimensional Wishart distribution with n degrees of freedom, on the covariance matrix Σ, and with noncentrality matrix $\delta = \mu'\mu$*. We write

$$W \sim W_p(n, \Sigma, \delta) \, .$$

Note that $\delta \geq 0$. If $\delta = 0$, we say that W has a *central Wishart distribution* and write

$$W \sim W_p(n, \Sigma)$$

If $\delta \neq 0$, we say that W has a *noncentral Wishart distribution*. Some properties of the Wishart distribution that follow directly from the definition are given by the following theorem :

THEOREM C.2 Let $W \sim W_p(n, \Sigma, \delta)$, then

1. $EW = n\Sigma + \delta$
2. If $p = 1$, $\Sigma = \sigma^2 > 0$, then $W \sim \sigma^2\chi^2_n(\delta/\sigma^2)$.

- If $a > 0$ is a scalar, then $aW \sim W_p(n, a\Sigma, a\Omega)$.

Finally, we give the following result for the central Wishart distribution.

THEOREM 6.8 If $W \sim W_p(n, \Sigma)$, $\Sigma > 0$, then the moment generating function of W is given by

$$M_W(Z) = |I - 2Z\Sigma|^{-n/2}, \quad \text{for a symmetric } Z \text{ such that } \Sigma^{-1} - 2Z > 0$$

Appendix D

The Fundamental Least-Squares Theorem

In this section we will prove (part of) the general fundamental least-squares theorem mentioned in section A.[illegible] (appendix A). First, we formulate and prove the following theorem:

THEOREM D.1 : Let $Y_i \sim N_p(\mu_i, \Sigma)$, for $i = 1, \dots, n$ and let A be a symmetric matrix of rank r, then

$$Y'AY \sim W_p(r, \Sigma, \Gamma), \text{ with } \Gamma = E[Y]'A\,E[Y] \text{ if and only if } A = A^2 .$$

PROOF

"⇒" Since A is symmetric, there exists an orthogonal matrix P, such that

$$P'AP = \Upsilon = \begin{pmatrix} \lambda_1 & & & & & \\ & \ddots & & & 0 & \\ & & \lambda_r & & & \\ & & & 0 & & \\ & 0 & & & \ddots & \\ & & & & & 0 \end{pmatrix} ,$$

where Υ is a diagonal matrix with diagonal elements equal to the eigenvalues of A. Since A is idempotent, we have (see theorem B.2)

$$\lambda_1 = \dots = \lambda_r = 1 ,$$

and thus

$$P'AP = \Upsilon = \begin{pmatrix} I_r & 0 \\ 0 & 0 \end{pmatrix} .$$

We can write

$$A = P_1 P_1' ,$$

where P_1 is an $n \times r$ matrix of rank r created from P by deleting the last $n-r$ columns. Define

$$Z = P_1^t Y .$$

Then

$$Y^tAY = Z^t P_1^t A P_1 Z = \sum_{i=1}^{r} Z_i^t Z_i = Z_{(r)}^t Z_{(r)} ,$$

where $Z_{(r)} = (Z_1, \ldots, Z_r)^t$. Since

$$Z \sim N_{r,p}(P_1^t \mu, I, \Sigma) ,$$

it follows that

$$Y^tAY \sim W_p(r, \Sigma, \Gamma)$$

The noncentrality parameter is given by

$$\begin{aligned} \Gamma &= EZ_{(r)}^t EZ_{(r)} \\ &= \mu^t P_1 P_1^t \mu \\ &= \mu^t A \mu \\ &= EY^t A\, EY . \end{aligned}$$

⇐
Assume for simplicity that $\mu = 0$ (and $\Gamma = 0$). Let P, Y and Z be defined as above. Then

$$\begin{aligned} Y^tAY &= Z^tP^tAPZ = Z^t\Lambda Z \\ &= \lambda_1 Z_1^t Z_1 + \lambda_2 Z_2^t Z_2 + \cdots + \lambda_n Z_n^t Z_n . \end{aligned}$$

Since the Z_i are independent and

$$\lambda_i Z_i^t Z_i \sim W_p(1, \lambda_i \Sigma) ,$$

the moment generating function of Y^tAY is given by

$$(|I - 2\lambda_1 \Sigma T| \, |I - 2\lambda_2 \Sigma T| \cdots |I - 2\lambda_n \Sigma T|)^{-\frac{1}{2}} . \tag{D.1}$$

We also know that $Y^tAY \sim W_p(r, \Sigma)$, so its moment generating function is also given by

$$|I - 2\Sigma T|^{-\frac{r}{2}} . \tag{D.2}$$

Comparison of D.1 and D.2 yields

$$\lambda_1 = \lambda_2 = \cdots = \lambda_r = 1$$

So $I = P'AP$ is a diagonal matrix with diagonal elements equal to 0 or 1, and is therefore idempotent. It follows that

$$P'AP = P'APP'AP = P'A^2P$$

Hence

$$A = A^2 ,$$

which means that A is idempotent. If $\mu \neq 0$, then $\lambda_i X_i'X_i$ $(i = 1, \ldots, r)$ and $Y'AY$ have a noncentral Wishart distribution. This will only result in an extra term in D.1 and D.2 and the conclusion that $A = A^2$ will still hold.
□

We now proceed with the proof of the general fundamental least-squares theorem:

PROOF

1. By theorem B.1, we have

$$\begin{aligned} Q &= \min \mathrm{Tr}[(YA - X\beta A)'(YA - X\beta A)] \\ &= \min \mathrm{Tr}[\underbrace{(Y - X\beta)'(Y - X\beta)}\underbrace{AA'}] . \end{aligned}$$

So we might as well look at

$$Q' = \min \mathrm{Tr}[(Y - X\beta)'(Y - X\beta)] .$$

under $C\beta A = \Gamma$. Define

$$\begin{aligned} SS_E &= (Y - X\hat{\beta})'(Y - X\hat{\beta}) , \\ SS_E' &= (Y - X\hat{\beta}_0)'(Y - X\hat{\beta}_0) \\ SS_H &= SS_E' - SS_E , \end{aligned}$$

where $\hat{\beta}$ is the least square estimate in the large model Ω (section A.4) and $\hat{\beta}_0$ is the estimate under the hypothesis $C\beta A = \Gamma$. We proceed with a matrix Θ of Lagrange multipliers, so that we have to minimize the function

$$F = \mathrm{Tr}[(Y - X\beta)'(Y - X\beta)] - 2\mathrm{Tr}[\Theta'(C\beta A - \Gamma)] .$$

Writing

$$F = \mathrm{Tr}(Y'Y) - \mathrm{Tr}(Y'X\beta) - \mathrm{Tr}(\beta'X'Y) + \mathrm{Tr}(\beta'X'X\beta) - 2\mathrm{Tr}(\Theta'C\beta A) + 2\mathrm{Tr}(\Theta'\Gamma) ,$$

the partial derivatives of F with respect to β and Θ are

$$\frac{\partial F}{\partial \beta} = -2X'Y + 2X'X\beta - 2C'\Theta A'$$
$$\frac{\partial F}{\partial \Theta} = 2C\beta A - 2\Gamma .$$

Equating to zero yields

$$(X'X)\beta_0 - C'\Theta A' = X'Y , \qquad (D.6)$$
$$C\beta_0 A = \Gamma . \qquad (D.7)$$

Using theorem D.5 we obtain

$$\beta_0 = (X'X)^{-1}(X'Y + C'\Theta A') = \hat{\beta} + (X'X)^{-1}C'\Theta A' .$$

We write this as

$$(X'X)^{-1}C'\Theta A' = \hat{\beta} - \beta_0 ,$$

and multiplying by C and A gives

$$C(X'X)^{-1}C'\Theta A'A = C\hat{\beta}A - C\beta_0 A = C\hat{\beta}A - \Gamma .$$

The last equality follows from D.7. So now we have the following expression for Θ:

$$\Theta = (C(X'X)^{-1}C')^{-1}(C\hat{\beta}A - \Gamma)(A'A)^{-1} . \qquad (D.8)$$

The matrix $(C(X'X)^{-1}C')^{-1}$ exists because it is a $g \times g$ matrix of rank g, and $(A'A)^{-1}$ exists because it is a $u \times u$ matrix of rank u. Together with D.6 and theorem D.5 we have

$$
\begin{aligned}
SS_0 &= (Y - X\beta_0)'(Y - X\beta_0) \\
&= (Y - X\hat{\beta} + X(X'X)^{-1}C'\Theta A')'(Y - X\hat{\beta} + X(X'X)^{-1}C'\Theta A') \\
&= SS_1 + A(A'A)^{-1}(C\hat{\beta}A - \Gamma)'(C(X'X)^{-1}C')^{-1}(C\hat{\beta}A - \Gamma)(A'A)^{-1}A' ,
\end{aligned}
$$

or

$$SS_h = SS_0 - SS_1 = A(A'A)^{-1}(C\hat{\beta}A - \Gamma)'(C(X'X)^{-1}C')^{-1}(C\hat{\beta}A - \Gamma)(A'A)^{-1}A' .$$

Further

$$
\begin{aligned}
SS_E^* &= (Y - X\hat{B})'(Y - X\hat{B}) \\
&= Y'Y - Y'X\hat{B} - \hat{B}'X'Y + \hat{B}'X'X\hat{B} \\
&= Y'Y - \hat{B}'X'Y - (X'Y - X'X\hat{B})'\hat{B} \\
&= Y'(I - X(X'X)^{-}X')Y .
\end{aligned}
$$

Finally we obtain

$$
\begin{aligned}
SS_E &= (YA - X\hat{B}A)'(YA - X\hat{B}A) \\
&= A'SS_E^*A \\
&= A'Y'(I - X(X'X)^{-}X')YA ;
\end{aligned}
$$

and since

$$
SS_L = (YA - X\hat{B}_c A)'(YA - X\hat{B}_c A) = A'SS_L^*A ;
$$

we have

$$
\begin{aligned}
SS_H &= SS_L - SS_E = A'(SS_L^* - SS_E^*)A = A'SS_H^*A \\
&= (C\hat{B}A - \Gamma)'(C(X'X)^{-}C')^{-1}(C\hat{B}A - \Gamma) .
\end{aligned}
$$

2. We write SS_H as

$$
SS_H = R'\underbrace{X(X'X)^{-}C'(C(X'X)^{-}C')^{-1}C(X'X)^{-}X'}_{Z}R ,
$$

with $R = YA - XC'(CC')^{-1}\Gamma$, since for some matrix M, $C = MX$ and $X = X(X'X)^{-}(X'X)$ (see theorem B.3). Then

(a) Z is symmetric and idempotent and of rank g.
(b) $R \sim N_{n,q}(XBA - XC'(CC')^{-1}\Gamma, I_n \otimes (A'\Sigma A))$.

By invoking theorem D.1 we now can establish that

$$
SS_H = R'ZR \sim W_q(g, A'\Sigma A, \Gamma_H) ,
$$

where

$$
\begin{aligned}
\Gamma_H &= ER'\,Z\,ER \\
&= \mu_R'X(X'X)^{-}C'(C(X'X)^{-}C')^{-1}C(X'X)^{-}X'\mu_R \\
&= (CBA - \Gamma)'(C(X'X)^{-}C')^{-1}(CBA - \Gamma) .
\end{aligned}
$$

with $\mu_{YA} = X\beta A - XC'(CC')^{-1}\Gamma$. And since

$$SS_e = A'Y'[I - X(X'X)^{-1}X']YA\ ,$$

with

$$YA \sim N_{N,q}(X\beta A, I_N \otimes A'\Sigma A)\ ,$$

we also establish that

$$SS_e \sim W_q(N - r, \Sigma, \Gamma_e)\ ,$$

since the matrix $I - X(X'X)^{-1}X'$ is symmetric, idempotent and of rank $N - r$ ($r =$ rank(X)). Further

$$\begin{aligned}
\Gamma_e &= E(YA)'[I - X(X'X)^{-1}X']E(YA)\\
&= A'\beta'X'[I - X(X'X)^{-1}X']X\beta A\\
&= 0\ ,
\end{aligned}$$

so SS_e has a central Wishart distribution. To prove independence of SS_e and SS_h, we write (see theorem B.3)

$$\begin{aligned}
SS_e &= A'Y'[I - X(X'X)^{-1}X']YA\\
&= [YA - XC'(CC')^{-1}\Gamma]'[I - X(X'X)^{-1}X'][YA - XC'(CC')^{-1}\Gamma]\\
&= R'[I - X(X'X)^{-1}X']R\ .
\end{aligned}$$

and

$$\begin{aligned}
SS_h &= SS_r - SS_e\\
&= (C\hat{\beta}A - \Gamma)'[C(X'X)^{-1}C']^{-1}(C\hat{\beta}A - \Gamma)\\
&= [C(X'X)^{-1}X'YA - \Gamma]'[C(X'X)^{-1}C']^{-1}[C(X'X)^{-1}X'YA - \Gamma]\\
&= R'X[(X'X)^{-1}]'C'[C(X'X)^{-1}C']^{-1}C(X'X)^{-1}X'R\ ,
\end{aligned}$$

since $C = MX$ for some matrix M, and

$$[C(X'X)^{-1}X'][XC'(CC')^{-1}] = I_g\ .$$

Thus the quadratic forms SS_e and SS_h both have the same form and

$$[I - X(X'X)^{-1}X'][X[(X'X)^{-1}]'C'[C(X'X)^{-1}C']^{-1}C(X'X)^{-1}X'] = 0.$$

The matrices of the quadratic forms are both symmetric and idempotent and their product equals zero, so we therefore may conclude that SS_e and SS_h are independent (Timm, 1975, p. 118).

3. The distribution of Λ is the distribution of a product of p independent beta variables with parameters $(\nu_e - i + 1)/2$ and $\nu_h/2$. For a detailed proof, the reader is referred to Anderson (1958, Chap.8).

$\square$

In the special case that $p = 1$ and $p = 2$ we have

$$p = 1: \quad \frac{1 - \Lambda}{\Lambda} \frac{\nu_e}{\nu_h} \sim F_{\nu_h, \nu_e}$$

$$p = 2: \quad \frac{1 - \sqrt{\Lambda}}{\sqrt{\Lambda}} \frac{\nu_e - 1}{\nu_h} \sim F_{2\nu_h, 2(\nu_e - 1)}$$

Anderson (1958) gives a proof of this result.

Appendix E

Figures

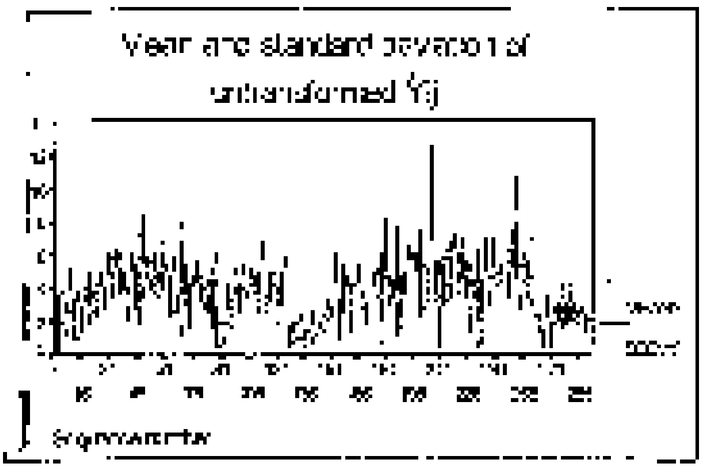


figure 1

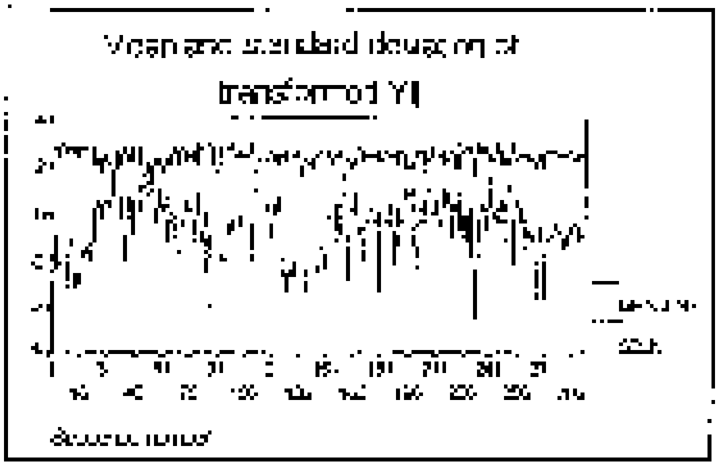


figure 2

Figure 3a: QQ plot of sample 1

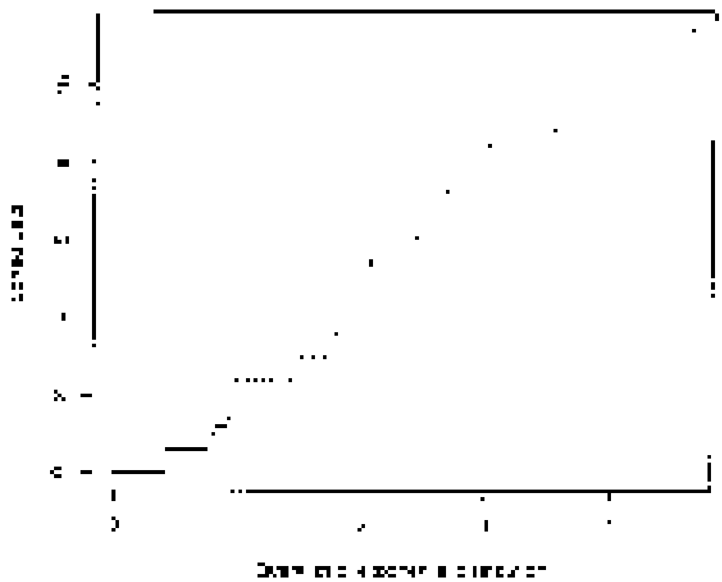


Figure 3b: Histogram of sample 1

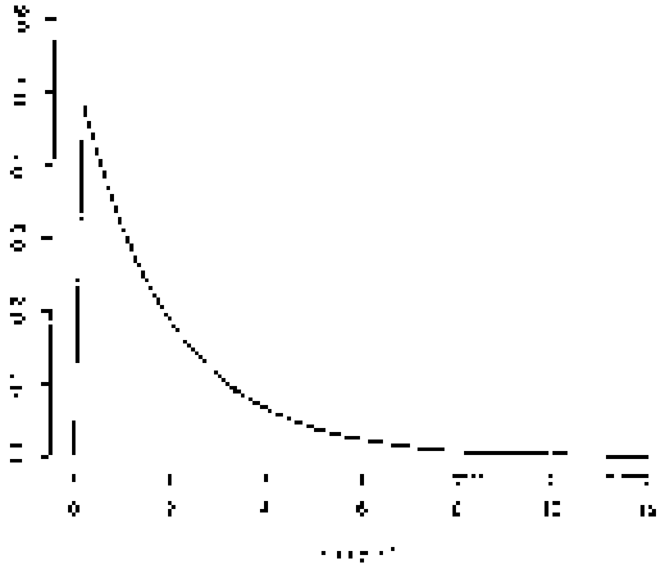


Figure 4a: QQ-plot of sample 2

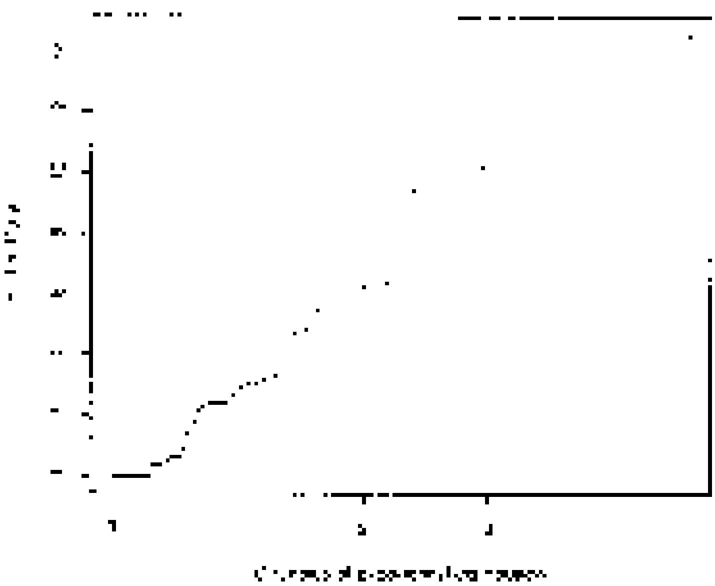


Figure 4b: Histogram of sample 2

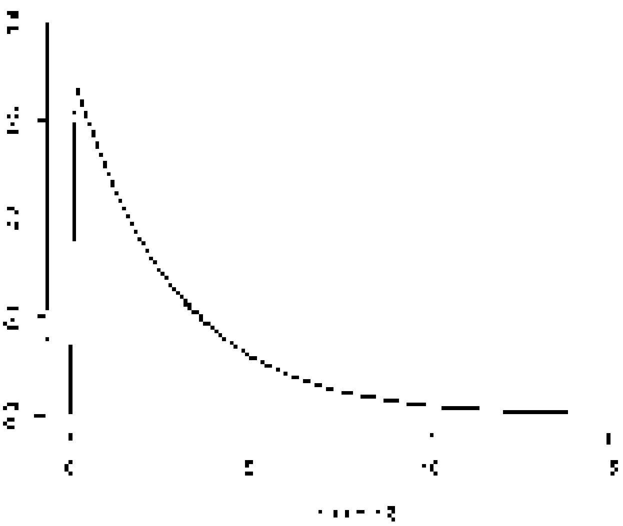


Figure 5a: QQ-plot of sample 3

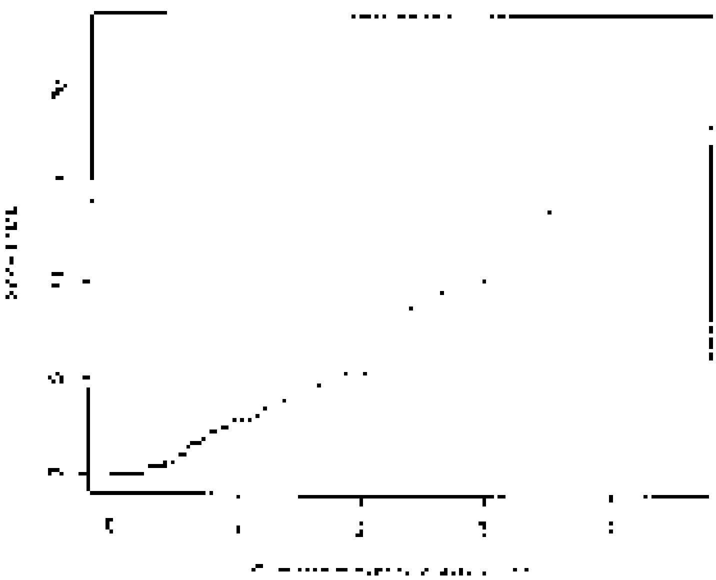


Figure 5b: Histogram of sample 3

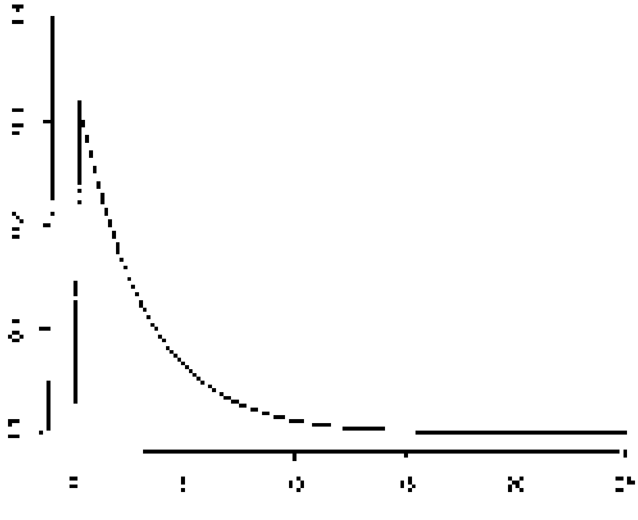


Figure 6a: QQ plot of sample 4

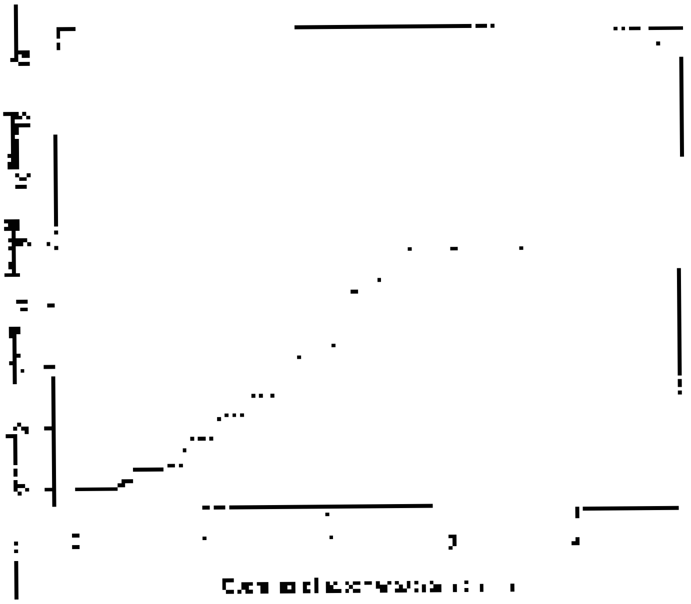


Figure 6b: Histogram of sample 4

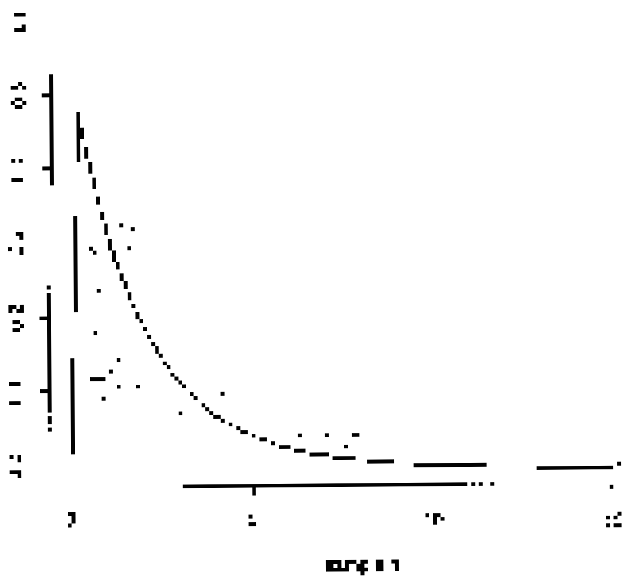


Figure 7a: QQ plot of sample 5

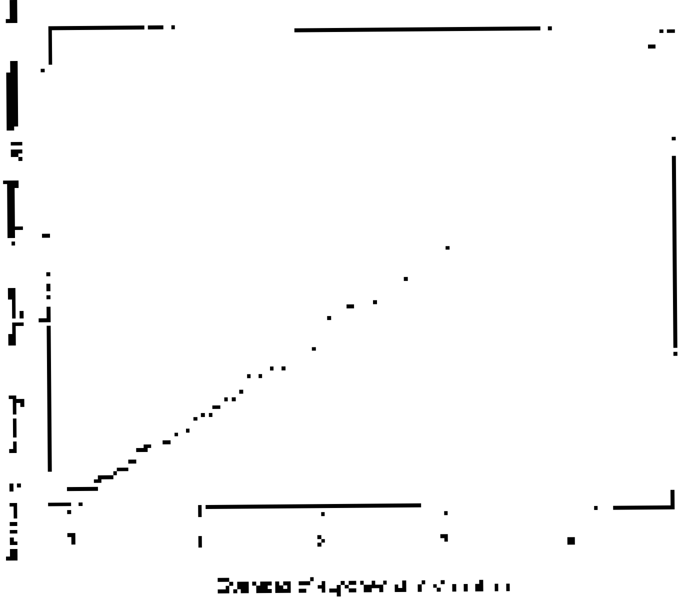
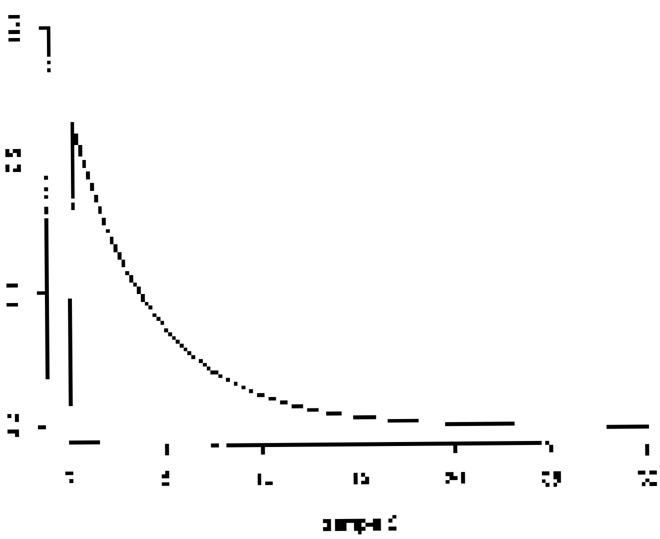


Figure 7b: Histogram of sample 5



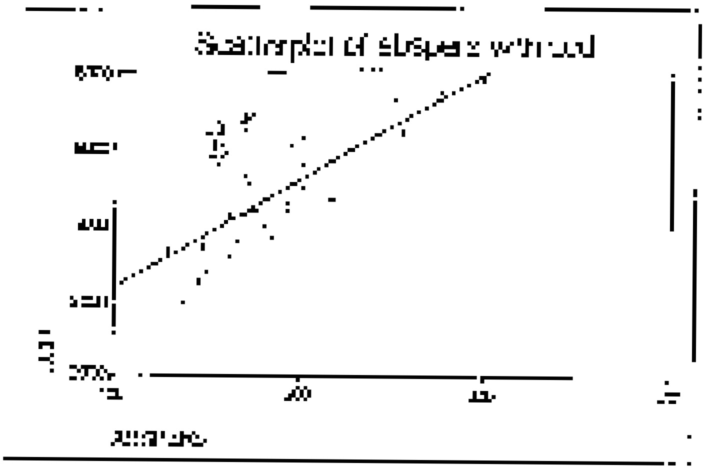


figure 8

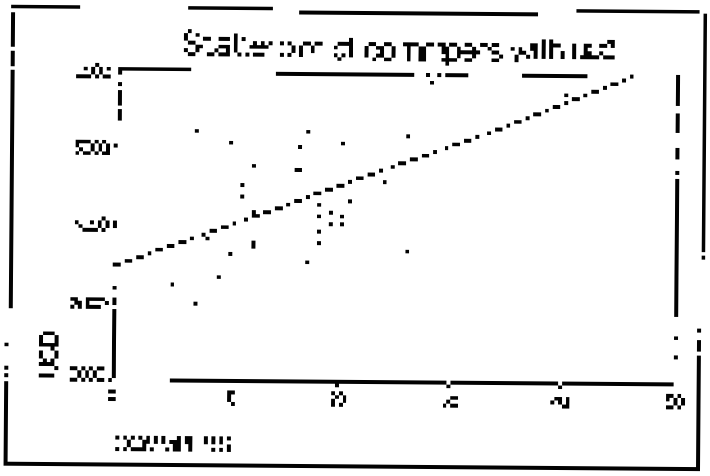


figure 9

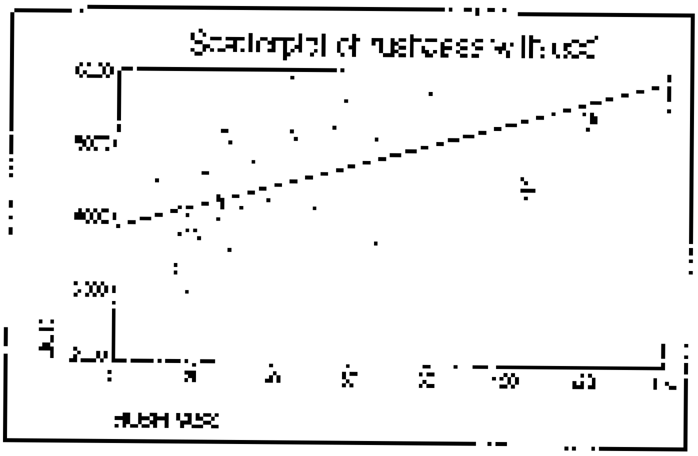
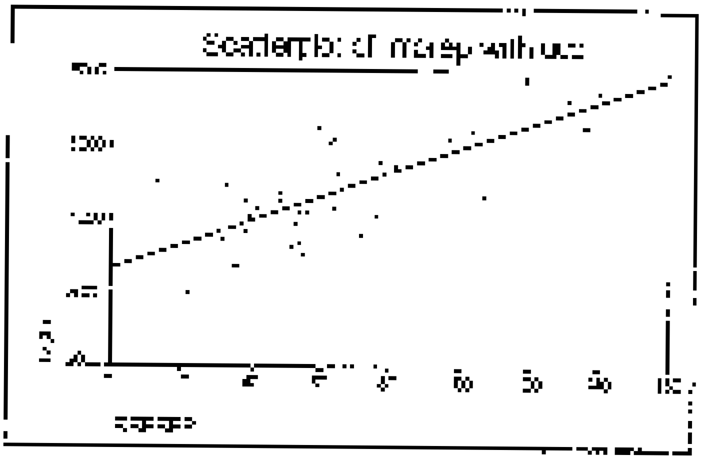


figure 10



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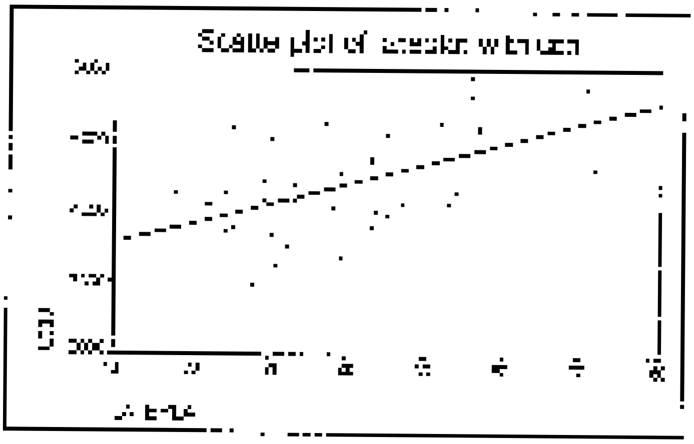

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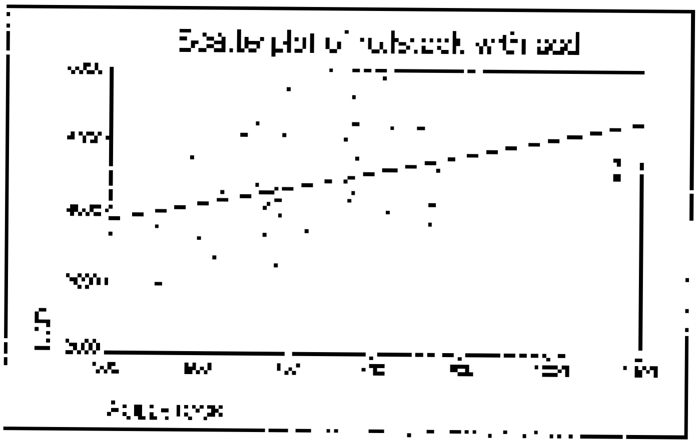

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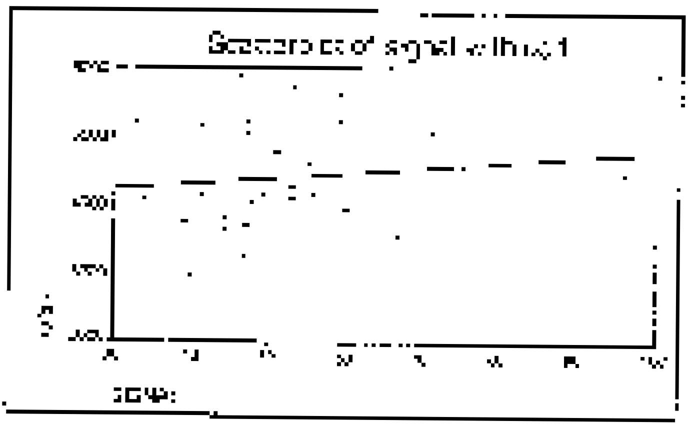

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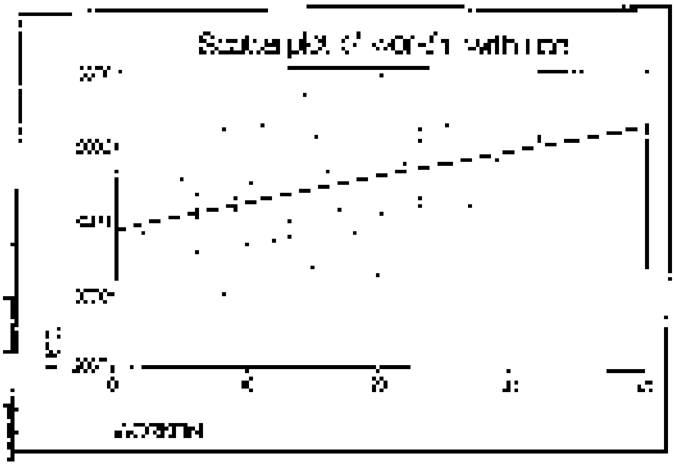

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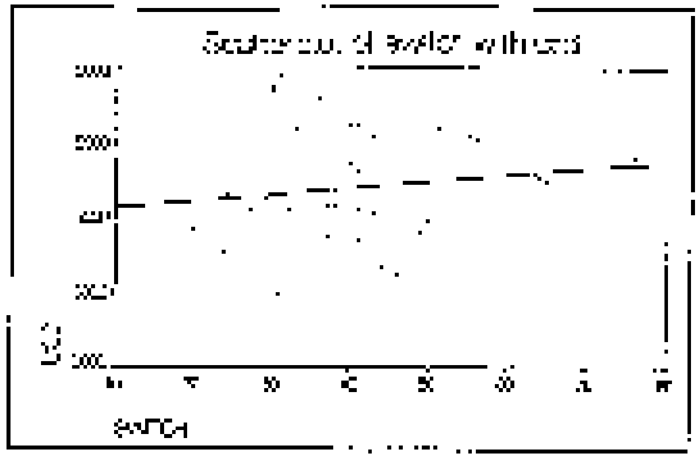


Figure 16

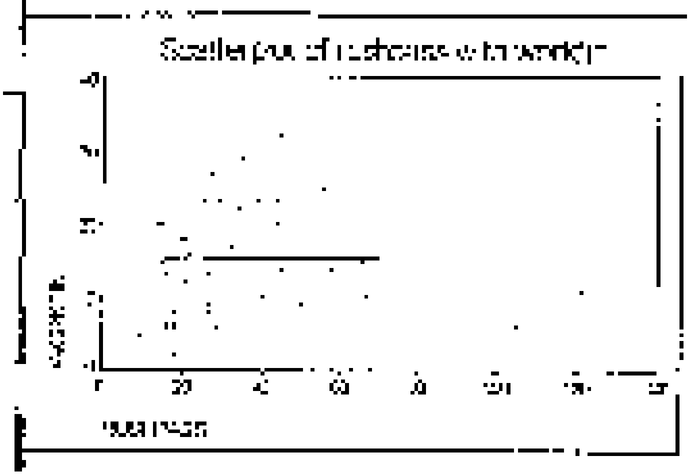
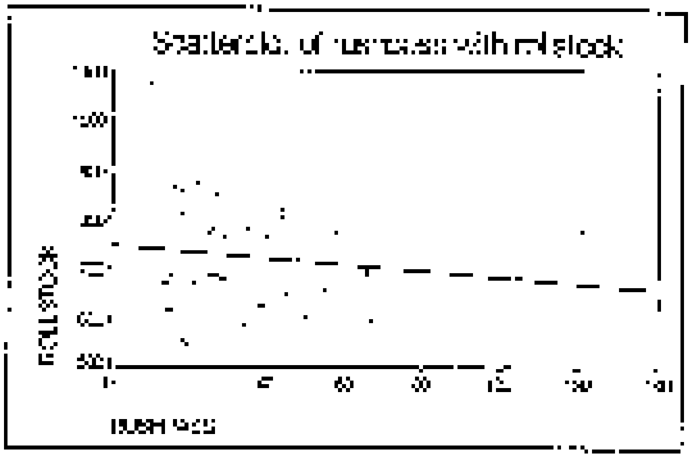


Figure 17



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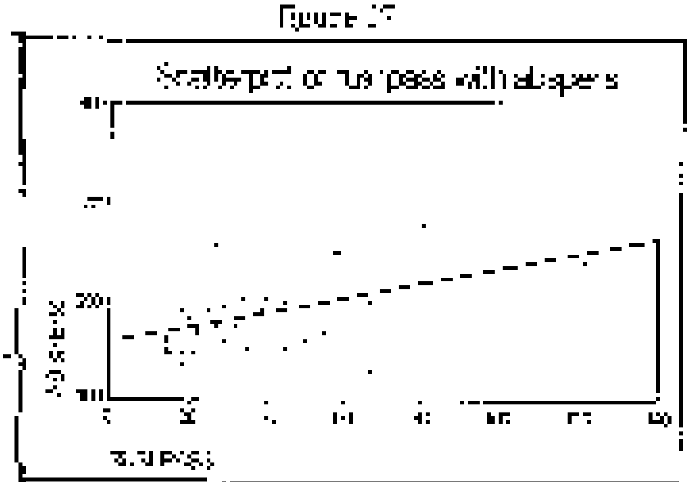
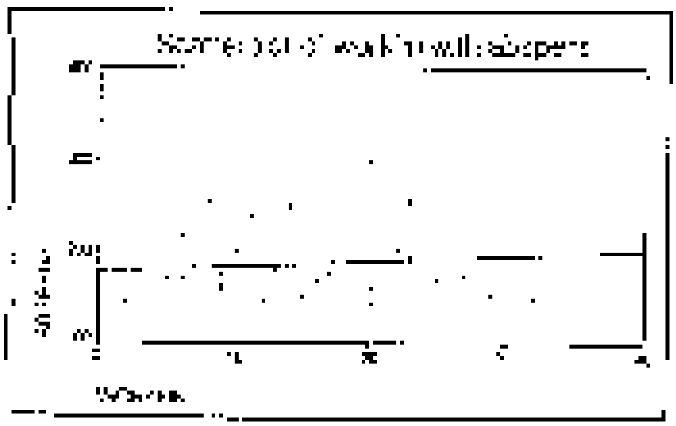


Figure 19

Figure 20



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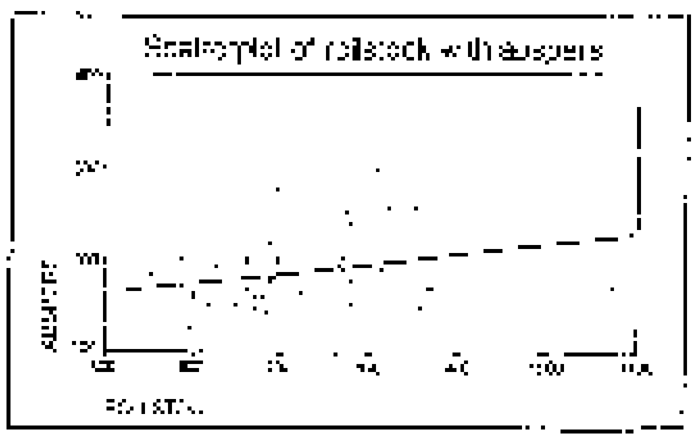

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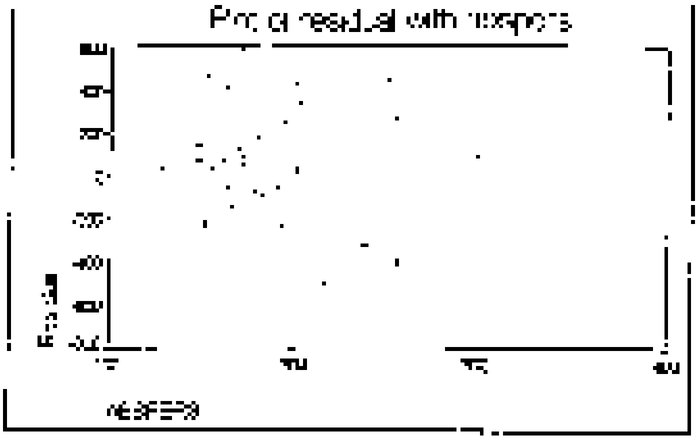

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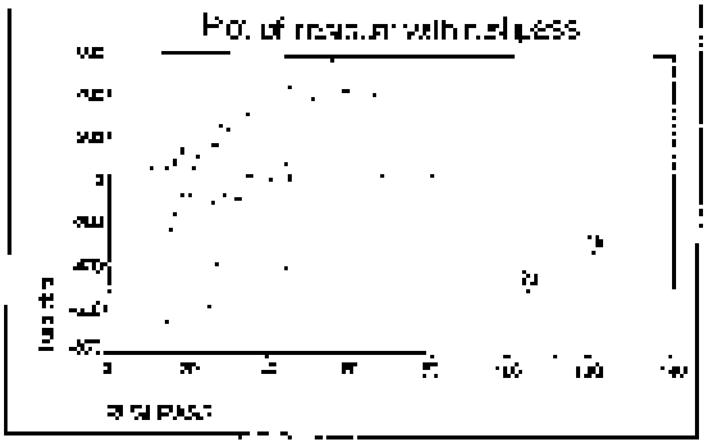

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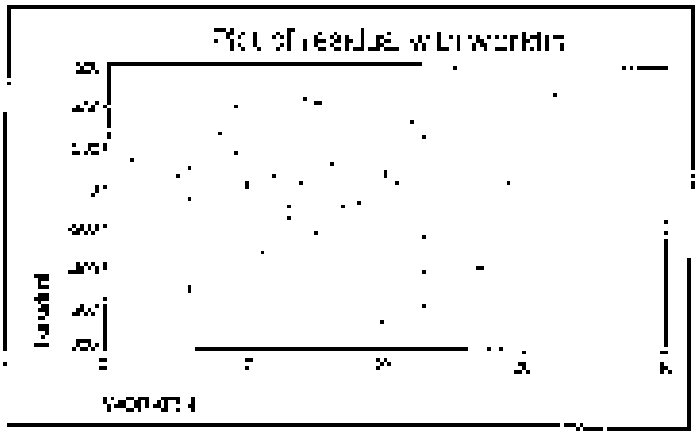

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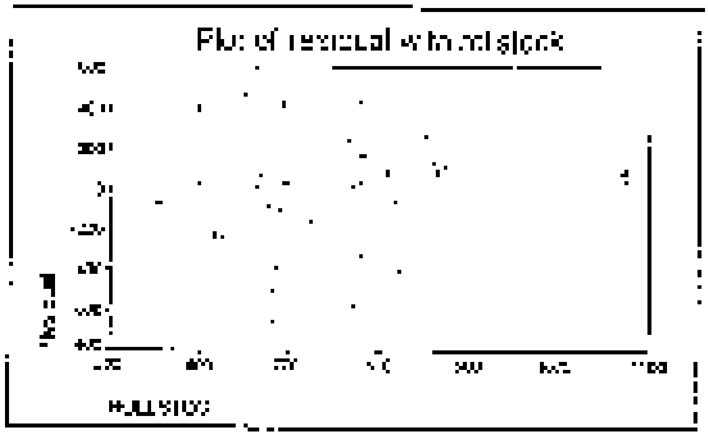

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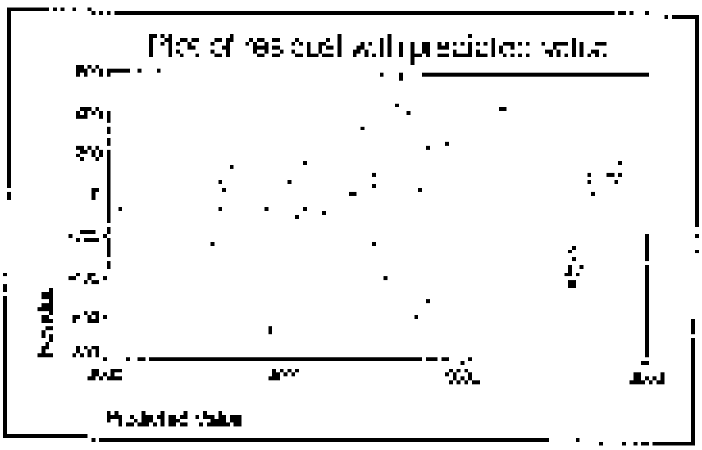

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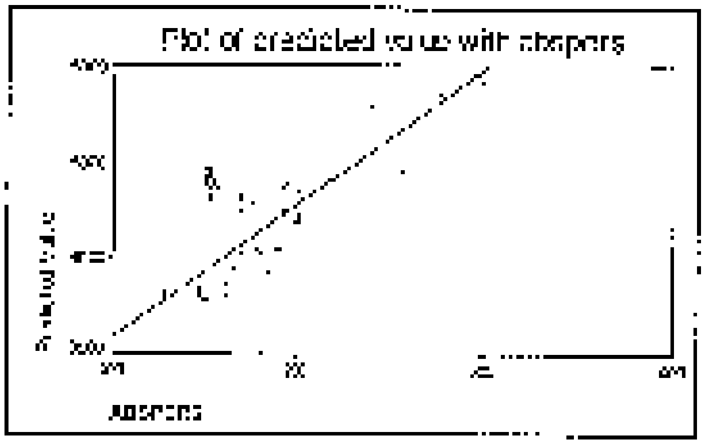

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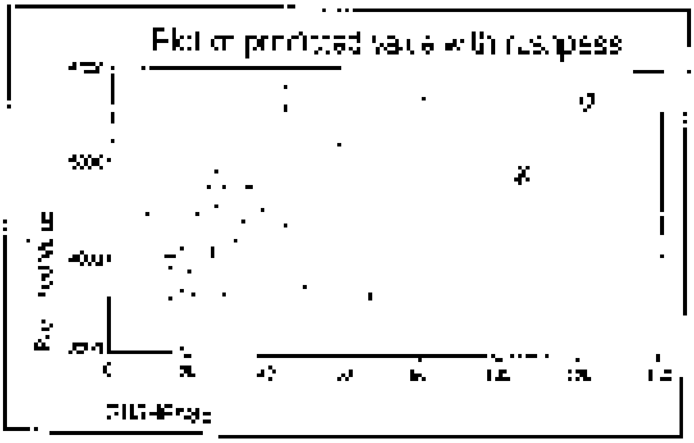

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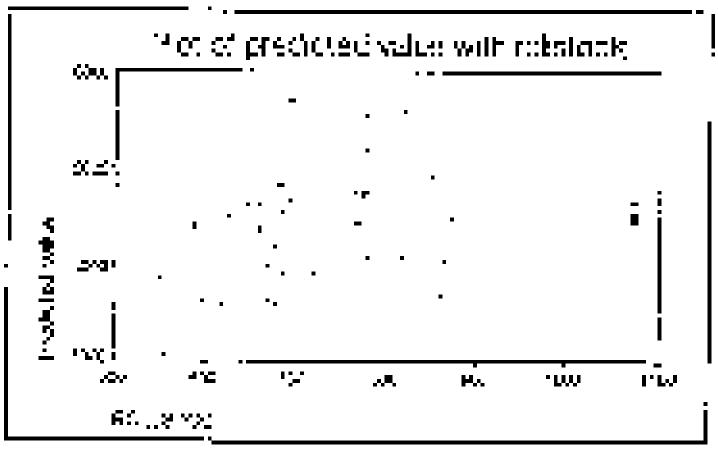

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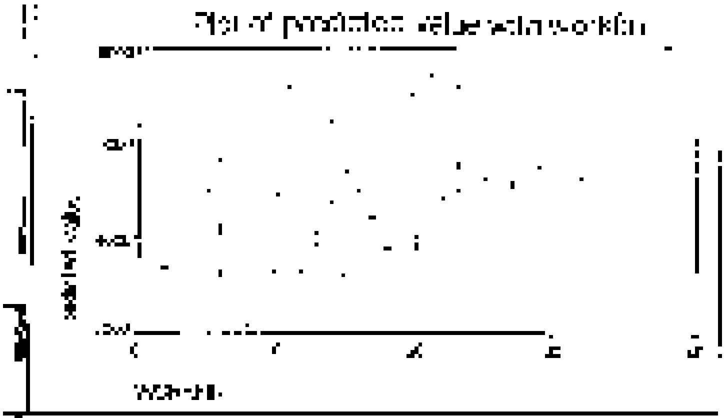

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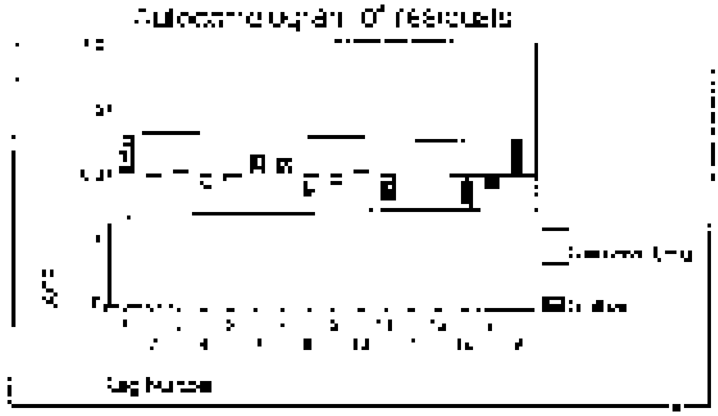

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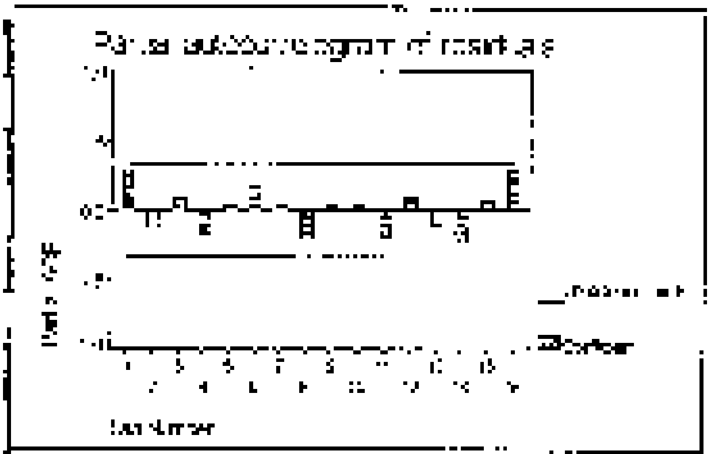

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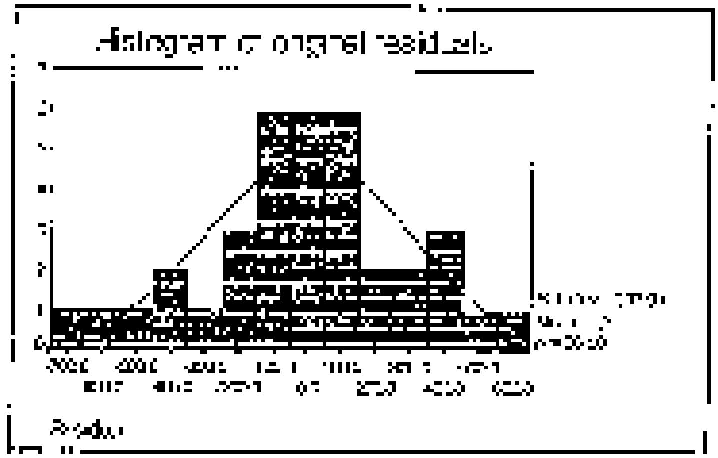

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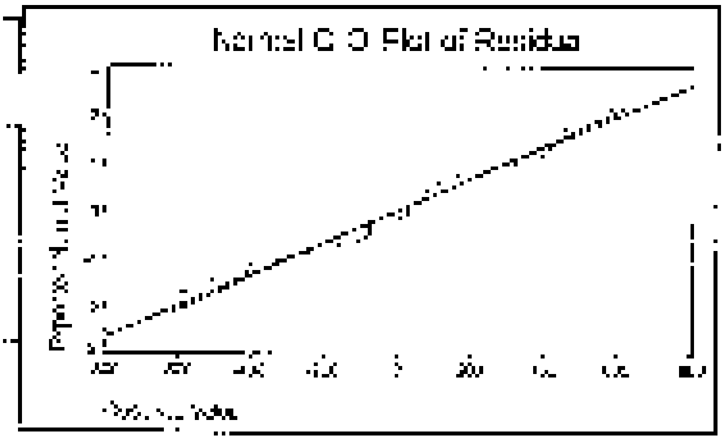

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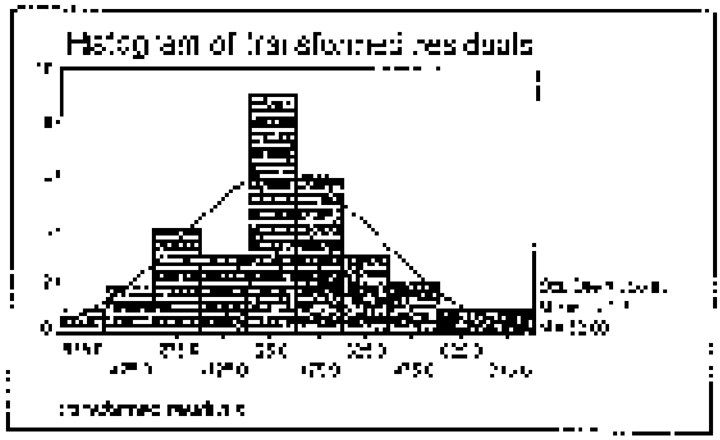

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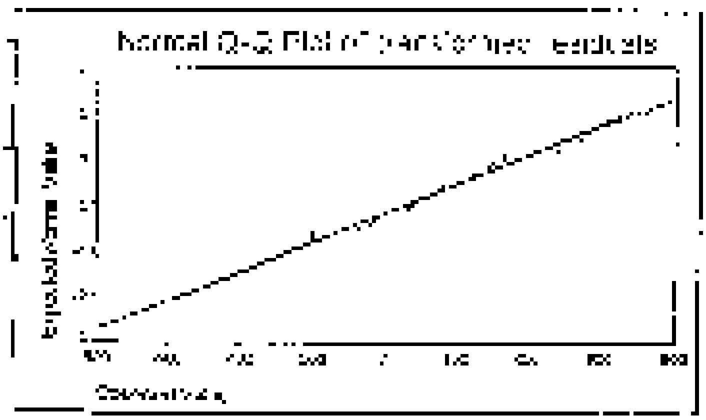

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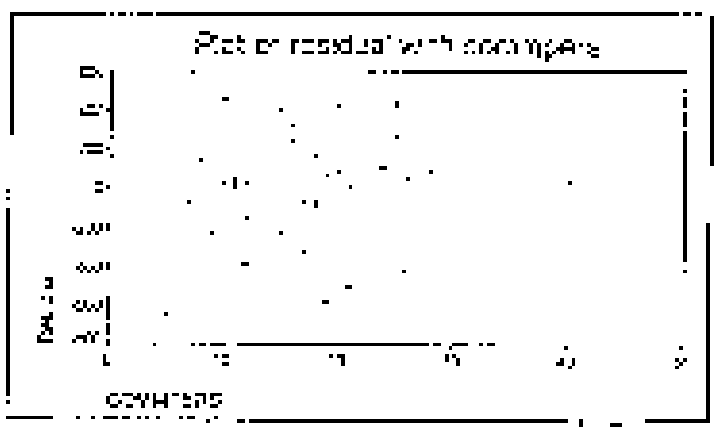
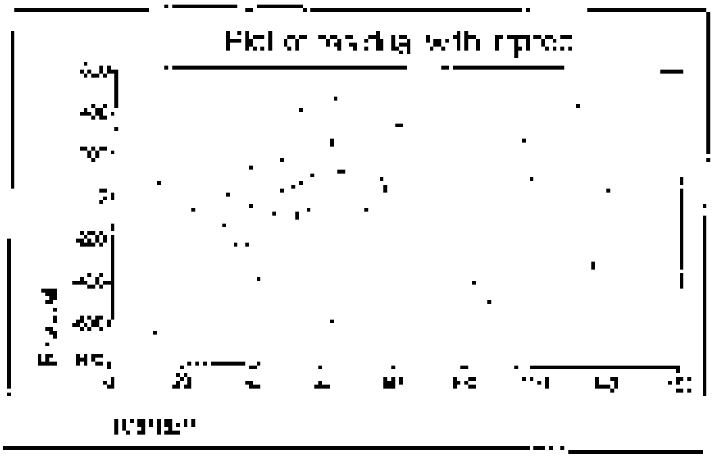
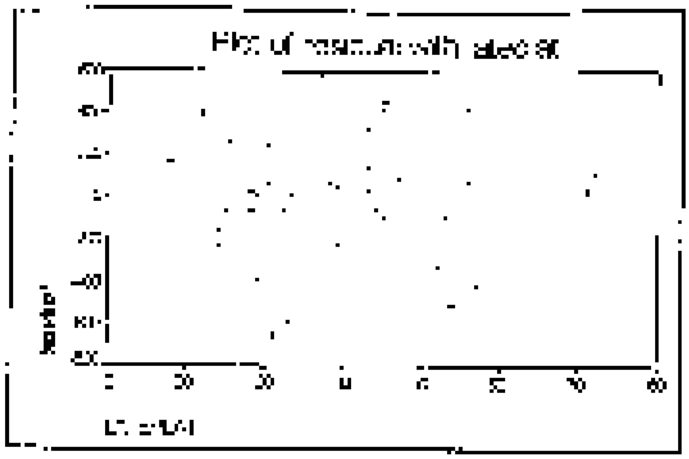


figure 38





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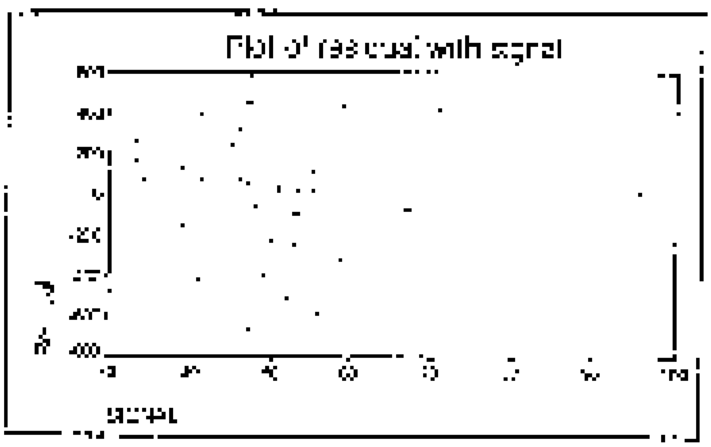

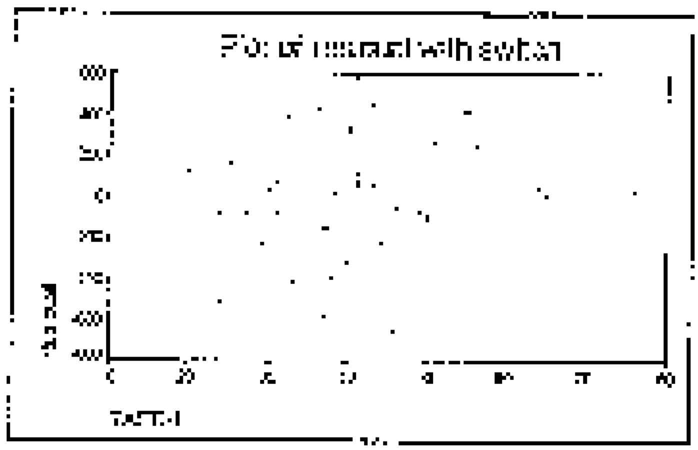

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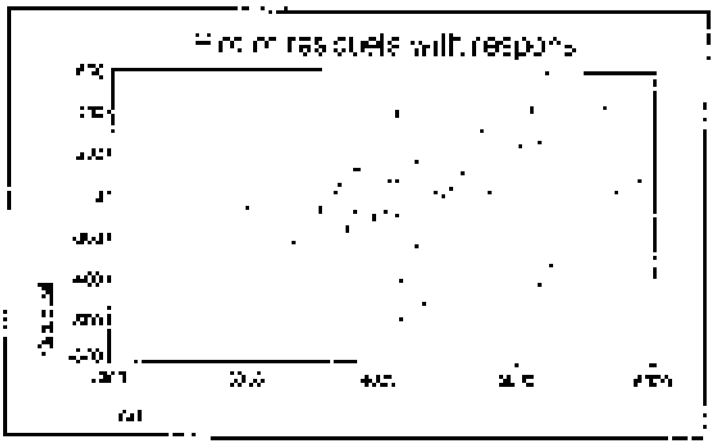

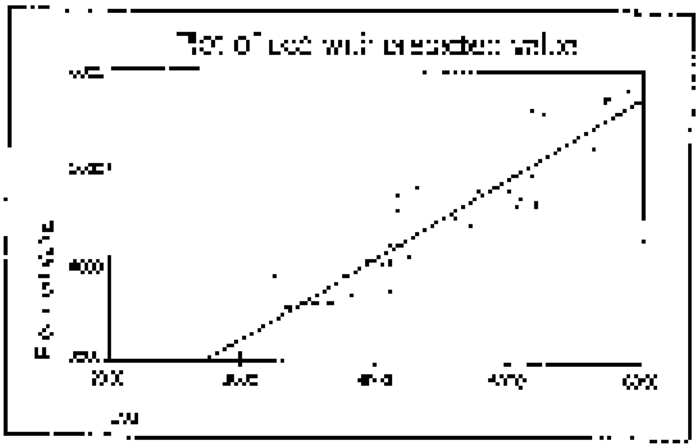

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1996 CAPE TOWN

7 October - 9 October 1996
The Lord Charles Hotel, Cape Town, South Africa

Paper 9625

Christi Thompson

Risk Information Management in Spoornet

CURRICULUM VITAE

Christi Thompson

Christi currently heads the Risk Information Systems of Spoornet's Risk Management Department. He started this section two years ago.

Before this, he held the following positions in Spoornet:

- Financial Manager (Metro), Head Office
- Head of Research (Passenger Services), Head Office
- Statistician (East London region)
- Researcher (Cost Accounting), Head Office

Christi holds a B.Comm degree in Transport economics and Business Economics, and has obtained various diplomas in the field of finance and risk management.

His paper ;

"The future role of Rail Commuter Transport in South Africa"

was judged as the best paper at the Annual Transport Convention in Pretoria in 1986.

INTERNATIONAL RAILWAY SAFETY CONFERENCE

CAPE TOWN: OCTOBER 1996

TITLE: **RISK INFORMATION MANAGEMENT IN SPOORNET**

AUTHOR: **CHRISTI ANTHONIE THOMPSON**
MANAGER
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RISK MANAGEMENT
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SYNOPSES;

SPOORNET IS A HUGE ORGANISATION WITH RAILWAY LINES REACHING INTO ALL CORNERS OF SOUTH AFRICA AND EMPLOYING 50 000 PEOPLE.

ESTIMATES HAVE INDICATED THAT SPOORNET HAS A SUBSTANTIAL COST OF RISK. THE TRUE EXTENT IS HOWEVER NOT KNOWN DUE TO THE INADEQUACY OF RISK RELATED INFORMATION.

SPOORNET THEREFOR DECIDED THAT A COMPREHENSIVE, MAINFRAME BASED RISK RELATED INFORMATION SYSTEM SHOULD BE DEVELOPED TO ADDRESS ALL ASPECTS OF A WORLD CLASS RISK MANAGEMENT PROCESS.

THIS LEAD TO THE ESTABLISHMENT OF PROJECT RIMAS (RISK INFORMATION MANAGEMENT IN SPOORNET).

THIS PAPER BRIEFLY DESCRIBES THE RIMAS COMPUTERISED INFORMATION SYSTEM. IT THEN DESCRIBES THOSE FEATURES OF RIMAS THAT DIFFERENTIATE IT FROM OTHER RISK RELATED SYSTEMS THAT ARE AVAILABLE.

INTRODUCTION

To manage without information, is not to manage at all.

The popular saying goes:

"If you don't know where you are going, it doesn't matter which road you take to get there".

Without information:

- you won't know where you are heading (or where you should be heading),

- you won't know which road you are taking to get there; (or which road you should be taking).

- you won't know when you deviate from this road (and remember, in the first place you didn't know which road it was); and

- worst of all, you won't even know where you are coming from.

Spoornet is a massive organisation with 21 000 route kilometres of track, 50 000 employees, and an annual turnover of about R8 000 million generated by moving 160 million tons of freight.

Spoornet also has a substantial cost of risk. In order to reduce this cost of risk and to ensure that Spoornet knows where it is coming from and where it is heading, one of Spoornet's initiatives is Project Rimas of the Risk Management department.

Rimas is the acronym for Risk Information Management in Spoornet. Rimas is a mainframe based computer system designed to integrate all information related aspects of a world class risk management process.

CONTENTS

1. HISTORICAL BACKGROUND TO RIMAS

When Risk Information Systems came into existence, just over two years ago, Spoornet consisted organisationally of ten regions and a head office, and ten different departments at each of these centres.

1.1 STATUS OF RISK INFORMATION AND INFORMATION SYSTEMS IN 1994.

The first task was to scan the available risk related information throughout this mammoth and complicated organisation.

The main characteristics of the information and information systems then in existence, were:

- information systems varied from manual paper systems through PC's used as word processors, to PC's properly applied;

  huge variances between regions and departments existed in respect of the types of information that were processed, the formats in which it was kept, the timing of information processing, etc.;

- various important types of information were not collated at all;

- very little integration of risk related information existed; and

- what was often kept was data, and when someone asked for useful information, expensive and time-consuming exercises ensued.

As Rimas is still in its first phase of development this situation is to some extent still prevalent.

1.2 THE EXTENT OF SPOORNET'S RISK RELATED LOSSES

In order to form an idea of what the scope of the system should be, to determine how much money and effort should be spent on the system, and to identify the critical risk areas which should first get attention, an investigation into the extent of Spoornet's risk related losses was conducted.

From the available information, and with some reliance on estimates, it emerged that the losses were substantial.

In order of decreasing magnitude the following types of risks were identified:

Asset related losses
Injuries on duty
Freight losses
Operating delays
Theft
Strikes
Third party claims
Fraud

The extent of Spoornet's risk related losses warranted a fair investment in a risk related information system.

1.3 THE DEVELOPMENT OF RISK MANAGEMENT IN SPOORNET

The Risk Management function in Spoornet was officially established about 3 years ago.

Naturally, certain elements of risk management had been practised for years by many managers- they just didn't know it was called risk management.

However, the systematic, holistic, process- driven approach to risk management really only started when the risk management function was officially established.

From an information point of view, the implication is that there was great uncertainty regarding the types of risk related information that should be available.

2. STRATEGIC GOALS

2.1 THE VISION OF RISK MANAGEMENT

The vision of Risk Management in Spoornet is:

"TO INTERNALISE A WORLD CLASS RISK MANAGEMENT PROCESS IN SPOORNET WHICH WILL VISIBLY ADD VALUE TO BUSINESS STRATEGIES"

2.2 PREDICTABLE SERVICE

In order to increase its market share the most important current business strategy of Spoornet is to deliver a predictable service. (Not predictably late, as some pessimists would have it, but to deliver a competitive, quality service).

The goal of Predictable Service is to get Spoornet operations to a level where all consignments will be delivered on time, every time

2.3 THE GOAL OF RISK INFORMATION SYSTEMS

In support of the vision of Risk Management and of the main business strategy of Spoornet, it is the goal of Risk Information Systems to assist line management in managing their risks to optimally acceptable levels by developing the required information and functional systems, as well as the supporting processes.

3. A GLIMPSE OF RIMAS

3.1 SPOORNET MANAGEMENT'S BRIEF REGARDING RIMAS

Management's brief to Risk Management was to develop the risk information system along the following guidelines.

- develop a mainframe based system which is fully integrated with other Spoornet information systems;

- utilise as far as possible existing mainframe workstations which is located countrywide;

- prevent fragmentation of risk related information by building a system which will accommodate and integrate all types of risk information;

- develop the system in conjunction with line management and take into account the requirements of all other stakeholders;

- integrate as far as possible all risk related activities, and therefor the Rimas system, with the normal functions, activities of line management; and

- do not re-invent the wheel, but as far as possible make use of existing software, where available and suitable.

3.2 THE MODULAR APPROACH OF FIMAS

From the research that was conducted and information that was gleaned during the Joint Application Development sessions, it soon became apparent that Fimas would be a project of formidable size.

Two options were considered:

- spend the next three years on development and then implement a fully fledged system in one go; or

- develop the system modularly and implement one module roughly every four months.

For the following reasons the modular approach was preferred:

i. anxiousness to get the first modules operational as soon as possible, particularly in respect of the more critical risk areas;

ii. pressure from insurers for an efficient reporting system;

iii. new legal requirements; and

iv. the inherent risks in developing a complete system before implementing.

3.3 THE OVERALL FRAMEWORK

As a starting point, the team developed an overall framework for the Russa project.

i. First the major risk categories which should be addressed in terms of Spoornet's holistic approach to risk management were identified.

These categories are:

- Pure risks;
- Commercial risks;
- IT risks; and
- Financial risks.

ii. Next the types of risks that would probably be found in each of these categories were determined.

For example, within Pure risks the following types were identified:

- asset losses;
- freight losses;
- injuries on duty;
- environmental losses; etc.
- Operational incidents

Within IT risks the following types were identified:

- hardware risks;
- software risks,
- process and procedures;
- staff risks; and
- legal risks

The parcelling of risks is essential because it was found that about 70% of the information requirements for the various categories and types of risks are completely different.

This means different screen designs, differences in the database, differences in information flow, etc.

Parcelling was also essential for the modular development approach

3.4 THE MODULES OF RIMAS

Through discussions with a wide spectrum of role players and research of the latest literature and practices regarding a world class risk management process, the Rimas team identified the following fifteen major modules of Rimas:

1. Incident management
2. Risk Identification
3. Risk Assessment
4. Risk classification
5. Risk profiling
6. Risk prioritising
7. Risk Costing
8. Risk accounting
9. Risk Financing
10. Risk Handling Plans/Programs
11. Risk Improvement Programs
12. Risk Monitoring
13. Risk MIS
14. Early Warning System
15. Functional Modules

Together, these modules form the overall framework for Rimas and the basis of establishing a world class risk information system within Spoornet.

5.4.1 Content of the modules

Describing the content of all the modules will require volumes of space. By way of example, the content of the Risk Costing module and the Risk Handling Plans/Programs module are briefly as follows:

i. *Risk Costing module*

Risk costing is more complex than it would appear. For instance, an incident actually has four variations of costs:

- costs for insurance purposes;
- costs for claims against third parties;
- costs for management purposes; and
- costs for accounting purposes.

The costing module will incorporate the different methodologies, formulae, templates, cost factors such as the cost per vehicle kilometre for various types of vehicles, labour charges and a host of other information to enable users to make the required cost calculations for each type of cost.

ii. *Risk handling plans/programs*

This module entails plans and programs to handle various types of risks should they materialise.

The type of plans we have in mind will include Emergency Plans, Disaster Recovery Plans and Business Continuity Plans.

Instead of these plans and programs being paper based and on a file that may be locked up in somebody else's office on the night that the disaster occurs, it will be available to all users on the system.

It will ensure that all users work according to the most recent version of the same plan.

All line managers will draw up their plans according to standardised formats which will be available on Rimas.

3.5 THE OBJECTIVES OF RIMAS

In order to support line management in managing their risks down to optimally acceptable levels, the broad objective of Rimas is:

To take the best of currently available risk related methodologies, techniques, formulae, etc., enhance it with our own knowledge, adapt it to our own requirements for different types of risk and provide it to line management in the form of user friendly computerised tools to enable them to perform their risk related functions in accordance with standardised yet tailor-made procedures.

More specific objective are:

i. to make visible the true extent, nature and cost of risk-related incidents to all levels of management;

ii. to supplement the information in respect of incidents by providing management with tools to identify, evaluate and prioritise all potential risks which may materialise;

iii. to support effective incident management e.g. reporting and notification, disaster recovery, incident investigation, recurrence preventative measures, claims and financing of the incident;

iv. to provide information and tools to enable management to prevent risks from materialising;

v. to provide a complete database of risk related information enabling analysis thereof e.g. to determine trends and identify frequent similar causes to monitor non-compliance to rules regulations and laws to measure performance against norms standards and benchmarks to make projections, etc., in order to support effective management decision making; and

vi. to eliminate the multitude of antiquated, cumbersome and isolated manual risk related systems currently in operation by providing an encompassing flexible and integrated computerised system.

4. DETAIL OF CHARACTERISTICS THAT DIFFERENTIATES RIMAS FROM OTHER RISK RELATED SYSTEMS

1. Rimas will incorporate the best methodologies, techniques, formulae, etc that are available

Although a multitude of risk related methodologies, techniques and formulae are available, existing off-the-shelf software packages have the disadvantage of employing only <u>certain</u> pre-selected methodologies, techniques and formulae.

In Rimas we will have the advantage of being able to select the best of what is available, adapt it to our own requirements and then build it into the system.

It may happen that we will select one methodology of e.g. risk assessment for pure risks, but another methodology for I.T. risks. On the one hand we will standardize, but on the other we will be flexible.

Whatever we select, we will know it is the best and most suitable for a particular application.

2. Line management will have access to standardised yet tailor-made screens, templates, methodologies etc.

At first glance "standardized yet tailor made" appears to be a contradiction in terms, but it need not to be.

Research has shown that about 30% of the information on various types of incidents are the same. These include time, date, place and reporter.

The other 70% is completely different for say an asset incident vs. a freight incident, or an IT- hardware incident vs. an IOD incident.

For this reason, although standardisation as far as possible is ideal, Rimas makes ample provision for practical differences.

Other systems often provide one generic incident reporting format. They try to accommodate every possible eventuality on this format. Due to complexity and diversity, they actually do not succeed in making half the people happy half the time, but rather in making everybody unhappy all of the time.

g. Rimas will be fully integrated with the other information systems of Spoornet.

i. The more important information systems of Spoornet all operate in a mainframe environment.

The integration of Rimas with the other systems has the following advantages:

- If a person's pension number is keyed in, the system will pull into Rimas that person's particulars from the Human Resource system. If a train no. is punched in, the system will pull in the particulars of that train from the Spiral system.

  Less information is therefore keyed in leading to time savings and presenting less scope for errors.

- the same information is not stored on two or more systems, leading to memory capacity savings; and

- the same information is in fact the same, and not different, as often happens when the "same" information is carried on different systems.

ii. In time provision will be made for electronic data interchange with external parties such as insurers and clients, e.g. for claims purposes.

h. Rimas will fully integrate all aspects of a world class risk management process, i.e. all modules of Rimas will be fully integrated with each other.

For example, the cost module will be linked to incident reporting module, which in turn will be linked to the claims module. The claims module again is linked to the insurance module.

Rimas therefor has the ability to assimilate information about all the various components of an incident and all the parties involved in that incident.

5. Rimas has a notification function consisting of various levels.

- The first level is to notify, by selection, all parties who must react to the situation (although we do not plan to replace telephonic notification);

- The second level is to prompt investigation into an incident.

- The third level is to illicit additional information, e.g. costs, from all parties that were involved in the incident.

  The fourth level is to notify the claims section, and through them, the insurers, of an incident.

The big advantage is that an incident is now captured only once, and not four or five times as was often the case in the past when every party involved logged the incident on its own system.

The capturer, who will be as close to the first point of contact as possible, will capture only generic information about an incident, e.g. time, place, what had happened, and who was involved.

Rimas will then require the capturer to select what was involved, e.g. freight, assets, injuries, operating and environment. Rimas will further require that the capturer selects who must be notified, e.g. Signals, Rolling Stock and Mainline Passenger Services.

From the what and who information and the terminal addresses of all the parties which reside on the system, all parties selected will be notified of the incident by the system.

Where applicable, these parties will then be provided with screens relating to their specific domain, requiring additional information about the incident to be captured, e.g. costs and time of crash of a wagon.

Security and Risk Management will be notified of all incidents as a standard procedure.

6. For accounting purposes, Rimas generates a unique number for every incident.

When an incident occurs Rimas generates a unique number for that incident. When work is performed in respect of the incident, this number is used by the technical departments on all works orders relating to that incident.

The works orders reside on the SAP accounting system and, through the unique number it allows us to extract the exact costs of an incident from the accounting system.

7. Rimas provides users with a function to update information.

Information regarding an incident is often initially not totally correct or complete, and we cannot expect it to be.

Rimas therefor allows updating of captured information as events develop and more reliable information becomes available.

This procedure holds certain inherent risks, such as may be encountered when the amount of a claim is changed, or the finding of an investigation is changed

To counter these risks Rimas incorporates two procedures:

- authority to effect changes are given only to selected parties and is controlled by ID numbers; and

- an audit trail exists whereby all changes can be traced to a ID number, a terminal, a date and time and nature of the change.

8. Rimas will provide fully integrated management information.

The management information of Rimas will first of all be fully integrated in the sense that information from the various modules of Rimas will be integrated.

For example, information from the freight claims module, the asset claims modules and IOD claims module will be integrated to give a true reflection of the total loss of a particular incident.

But then it goes one step further.

By employing what is termed the Data-warehouse, Rimas has access to various other types of Spoornet information

Through this functionality we could e.g. relate a train driver who was involved in an accident to the number of hours he was on duty, or we could relate the number of derailments on a certain section to the number of wagon kilometres on that section, and compare it to other sections.

We will therefor have the facility to not view risk related information in isolation, but to view it in relation to the broader Spoornet activities.

9. Rimas incorporates an Early Warning System.

This EWS will cover three basic elements:

i. E.g. when hazmat is transported on a particular train, all parties involved down the line will be informed. This will allow staff to be that little more alert and prepared for any eventuality.

(The same procedure could be followed for very high value consignments, but the probability of playing into the hands of criminal elements is still being considered).

ii. Users can be electronically notified of impending disasters e.g. floods or hurricanes

iii. Exception reports where certain types of incidents occur regularly.

10. Rimas is not only an information system, but also incorporates certain functional capabilities.

Functional modules refer to those modules of Rimes which are not there purely for information purposes. They are there to provide a computerised procedure for handling a functional activity that is currently done manually.

The best examples are the modules for handling freight, asset and IOD claims.

i. For example, up to a year ago an incident involving freight may or may not have been reported and investigated.

According to Common Law a freight claim can be lodged against Spoornet for a period of up to three years. Often when such a claim was received many months later, no record or evidence of the incident was available.

Rimes now enforces capturing of the incident and investigation thereof, the result of which is also captured.

When the claim is received, the claim is coupled to the incident and the investigation report through the freight consignment number.

This enables settlement of the claim within days rather than months as in the past.

ii. Regarding assets, generic information about the incident is first captured. The system then requires the initial user to select what was involved e.g. freight, assets and IOD. If the user selects assets, the system requires the user to select <u>who</u> must be notified, e.g. Signals, Track and Rolling Stock.

Riskus now notifies a designated person within each of those departments of the incident. Riskus also provides them with screens designed specifically for a particular type of asset incident and designed for their specific department.

These screens require that certain types of information must be provided by these departments, e.g. <u>estimated</u> repair costs.

The local Risk Manager is also informed of the incident as he is required to ensure that all information regarding the incident is captured by the various parties.

As the incident, with estimated costs, must be reported to the Insurer within 14 days, the system warns users after 12 days if information is still outstanding.

Once all information is captured, the Risk Manager "closes" the incident. The incident is then electronically transferred to Risk Finance at Head Office, from where it is sent to the Insurer.

The system then transfers the whole of the incident to the claims module, where the same procedure as above is repeated.

This is done to enable all parties to capture final details, e.g. <u>actual</u> repair costs, for the purpose of the claim, which must be submitted within 60 days.

Once the Risk manager "closes" the claim for that incident, the system generates a claim form at Head Office.

The system then tracks progress with the claim, e.g.:

- Forwarded to insurer
- Awaiting additional information
- Awaiting payment
- Payment received

11. Rimas has succeeded in not being an add-on to line management's functions, but to become an integral part thereof.

After we had developed the freight incident and freight claims modules, we embarked upon development of the asset incident and asset claims modules.

We recognised that about 70% of asset incidents, in terms of monetary values, were related to the trains operating environment.

During fact-sessions on regions we also learnt that the Operating department did not have a standardised incident reporting system in place.

We also knew of the urgency of attaining predictability of our train service.

We consequently devised a plan and a process whereby the Rimas system would be used in operating offices.

The crux of this process was that all parties who needed to know of an incident will be informed immediately when an incident is logged.

We do however not plan to replace the telephonic notification of parties who should know immediately.

The Joint Operations Office is responsible for the planning, monitoring and re-scheduling of train services countrywide.

Rimas affects the areas of predictable service in that the JOO will be one of parties that will immediately be notified of any rail related incident.

Although the JOO may already have been notified telephonically of the incident, the computerised notification will have the following benefits.

- the system presents the user with screens structured in such formats as to illicit all critical information about the incident from the reporter; and

- the fact that the reporter has to commit the information about the incident to the system will in itself inspire the reporter to greater accuracy.

The many instances of incomplete, inaccurate or vague reports is therefore expected to drop sharply.

This will allow the JOO, technical staff, etc., to react more effectively to the incident.

5. RIMAS' SUPPORT OF PREDICTABLE SERVICE

Rimas will support the attainment of predictable service by:

- providing line management with tools enabling them to minimise those incidents which can disrupt Spoornet's business processes;
- providing support for recovery in case of incidents to limit consequential losses;

- enabling line management to inform clients expediently of instances where the business processes was disrupted, enabling clients to take corrective actions; and
- enabling fast settlement of claims where clients' goods were damaged;

6. CONCLUSION

The overall goal is to minimise disruptions to the Spoornet business process. In reaching for this goal:

- the cost of risk will decline; and
  the strategic goal of Predictable Service will be supported;

It is confidently expected that Project Rimss will greatly contribute to these goals.

Spoornet has opted for an effective and efficient long term solution, rather than the quick-fix off-the-shelf option which normally in long run does not solve the whole problem.

Although the initial pace of development has been relatively slow and the price not cheap, Rimss is bound to prove itself beyond reasonable doubt.

1996 CAPE TOWN

7 October - 9 October 1996
The Lord Charles Hotel, Cape Town, South Africa

Paper 9626

Brian Jacobs
Danie Van Zijl

The Development of Information Systems for enhanced management of Metrorail infrastructure

CURRICULUM VITAE

Brian Jacobs

Brian Jacobs graduated as a B.Sc. Civil Engineer (Honours) in the early 70's and obtained his Masters degree in Business Administration in the 80's.

He has 20 years experience in a diverse working environment of which 7 years was in the private sector. As a Professional Engineer he gained good hands on experience in the various facets of general business management in both corporate and smaller organisations. He held various senior positions in industries such as the Steel and Timber Manufacturing environment. Project Management of multi-disciplinary commercial projects, engineering Consultancy, Construction and Service related industries in a competitive market.

After holding the post of General Manager (1988 - 1993) in the Property Management and Development Industry he was appointed by the SARCC (SA Rail Commuter Corporation) as General Manager in the Technical Department.

He is a member of the South African Institute of Civil engineers and is a member of the Railways and Harbours Division.

He is currently seconded to Metrorail as Senior Technical Advisor to the infrastructure department.

CURRICULUM VITAE

Danie Van Zijl

Danie Van Zijl graduated with a B Sc.(Civil Engineering) in 1958 from the University of Stellenbosch, South Africa. He joined the South African Transport Services at the end of the same year and up to 1965 had in several construction projects, viz. Steam locomotive depot remodeling, deviation of existing railway lines and the construction of new lines.

He has always been interested in the maintenance of the permanent way and made valuable contributions to the development of the "new Approach" to track maintenance. After a stint in head office as Senior Planning Engineer he is in 1981 appointed as Inspecting Engineer (Maintenance) in the office of the Chief Civil Engineer.
Subsequently he is promoted to Assistant Chief Civil Engineer and in 1988 to Chief Engineer (Infrastructure). In 1990, with the commercialization of S.A. Transport Services he transfers to Transnet group headquarters with a change in designation to Executive Manager (Technical Services)

His duties brought him into contact with the maintenance of heavy trafficked railway lines in which he developed a keen interest and in 1983 he is elected to represent South Africa as a Director on the Board of International Heavy Haul Association. In 1989, he is elected Vice Chairman of the Board and in 1991 becomes Chairman. A position he holds until June 1993

Danie Van Zijl is a Fellow of the South African Institute for Civil Engineers and has for many years served in the Management Committee of the Railways and Harbors Division of the South African Institute of Civil Engineers, also as Chairman

He is a Fellow of the Permanent Way Institute and for five years served as Vice President for the South African Section. He is still a member of the South African Committee for Railway Engineering.

He is currently employed on a contract basis by Metrorail as Executive Manager (Infrastructure).

INTERNATIONAL RAILWAY SAFETY CONFERENCE

SOMERSET WEST

7 - 9 OKTOBER 1996

The Development Of Information Systems for Enhanced Management of Metrorail Infrastructure

AUTHOR AND PRESENTER:

Brian N Jacobs Senior Technical Advisor

CO-AUTHOR :

Braam van Zyl Executive Manager (Infrastructure)

THE DEVELOPMENT OF INFORMATION SYSTEMS FOR ENHANCED MANAGEMENT OF METRORAIL INFRASTRUCTURE

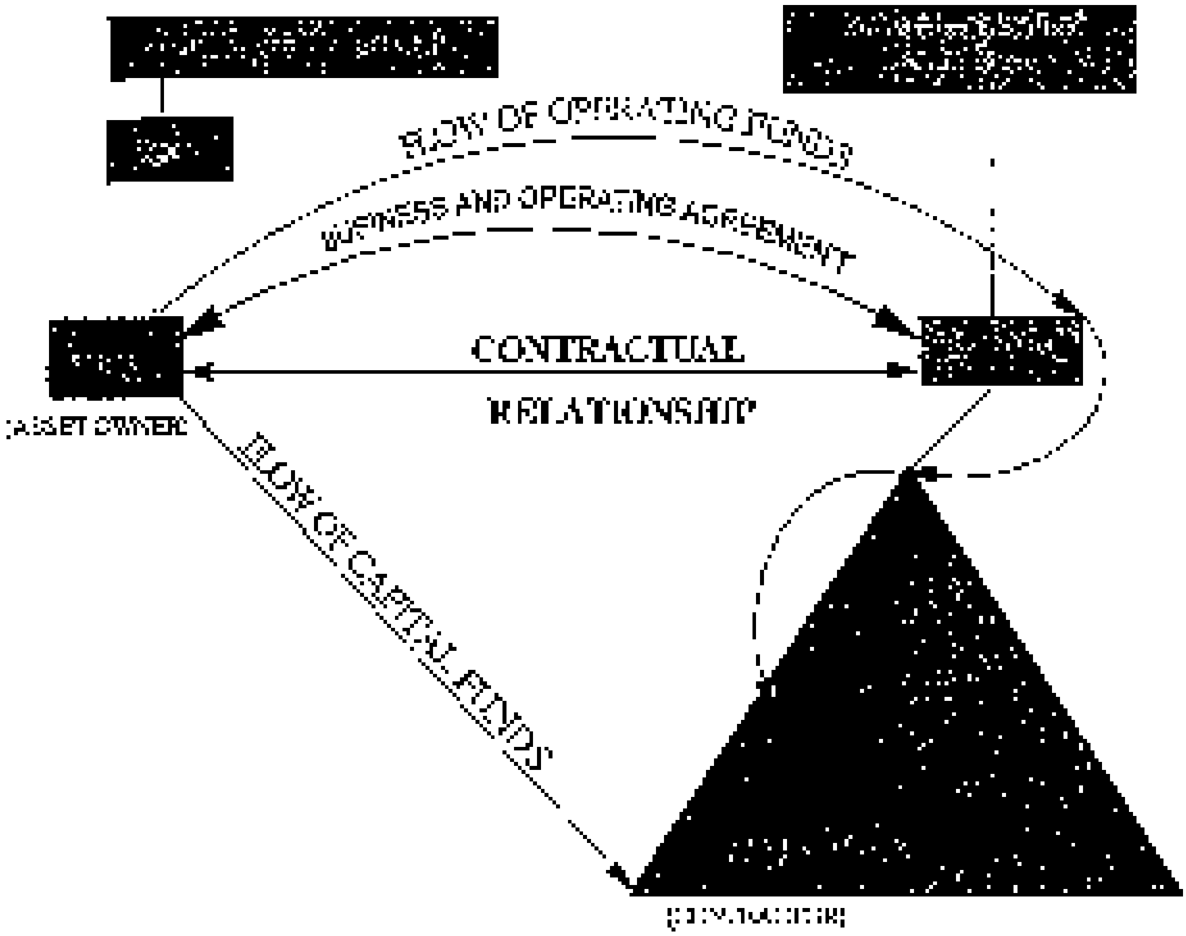
1. INTRODUCTION

Safety lies at the very heart of the Railway culture and we are faced with daily risks from Rail Infrastructure. Infrastructure is similar to the backstage functions of a production show. It is not apparent to the audience while the show is on, it is only when the curtain fails to rise or when the spotlight fails to light when the importance of the backstage operation becomes significant to the success of the show. As unimportant as our task may seem to our commuters, as challenging and essential it is to uphold and maintain safety standards and provide a reliable service to our commuters and internal customers.

2. CURRENT PERSPECTIVE

Suburban Rail Commuter services are currently being provided by Metrorail Services, a division of Spoornet, in terms of an concession operating agreement between the SA Rail Commuter Corporation (SARCC) and Transnet. The SARCC came into being as a commercial entity on 1 April 1990 in terms of the Legal Succession to the South African Transport Services Act, 1989 (Act no 9 of 1989). The SARCC became the owner of all the metropolitan rail commuter assets and presently functions similar to most suburban transport systems world-wide, being heavily subsidised by Central Government.

The suburban rail transport has over the past 15 years lost market share and the industry is now forced to reposition itself in order to attract commuters. This places tremendous pressure on Metrorail to become more competitive in the running of a safe and reliable business. At present there is no rail related competition, we compete against our own best performances which are monitored and benchmarked against world best practices. All this requires a major effort by the Infrastructure Department to become more efficient and effective in the management of the rail assets; track, signals and electrical.

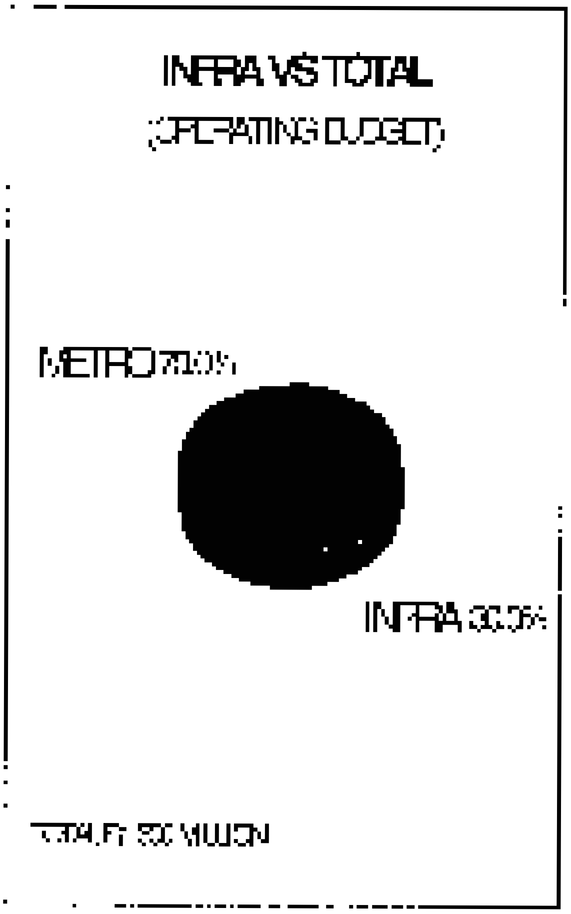

FLOW OF OPERATING FUNDS
BUSINESS AND OPERATING AGREEMENT
CONTRACTUAL
RELATIONSHIP
(ASSET OWNER)
FLOW OF CAPITAL FUNDS

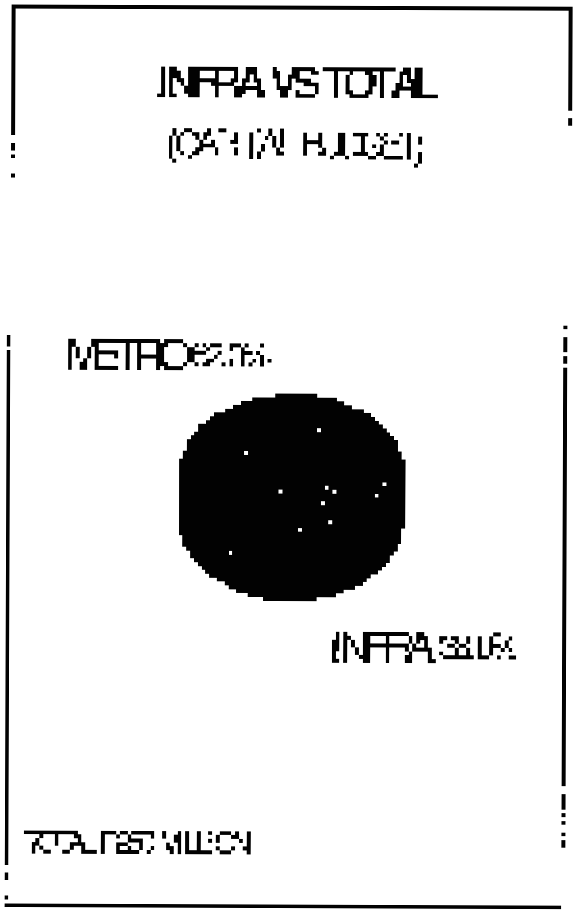
3 INFRASTRUCTURE ASSET BASE

Metrorail is under contract to manage the rail business with the following operational statistics:

OPERATIONAL STATISTICS FOR THE SUBURBAN RAIL COMMUTER SYSTEM	
Length of electrified rail track	2 220 km
Number of stations served	[illegible]
Trainsets	360
Motor and Trailer Coaches	4 555
Train trips per annum	786 080
Train kilometres per annum	[illegible] million
Passenger journeys per annum	[illegible] million
Passenger kilometres per annum	[illegible] million
Passenger trips per day (weekdays)	1.4 million
Number of employees: Metrorail	10 500

Infrastructure's operational spending per annum is ± R[illegible]m of which is 30% of the total Metrorail operational budget and has a ± R[illegible]m capital budget per annum. Infrastructure has a staff complement of 3 300 employees.

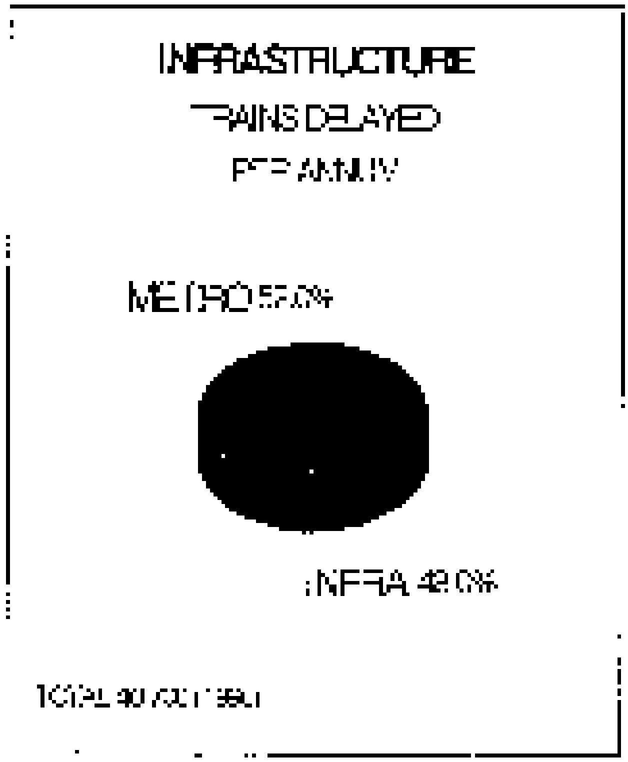




4. INFRASTRUCTURE FOCUS

Infrastructure is part of the whole supply chain to provide water to the consumer and has a major influence on the provision of a safe and reliable service. We see our major focus to improve the service by being more predictable in terms of operational readiness and risk assessment. Predictability from an Infrastructure perspective is the ability to constantly be forewarned of potential asset related failures and defects

The SARCC / [illegible] agreement is performance based and penalises delays and cancellations caused by Metrorail. The largest contributor is failure due to defects in [illegible] condition.



Only continuous [illegible] management of the assets will improve service levels. The [illegible] of Infrastructure require attention to the following:

1. Improved asset management

2. Ensure a more productive workforce

3. Improved maintenance planning

4. More proactive response to safety

5. Improve fault finding mechanisms and in so doing reduce train delays and cancellations and improve operational excellence

To achieve the above we need to focus on our core responsibilities and improve communication with our internal clients.

5. EARLY WARNING SYSTEM

Companies that are skilled in anticipating change in asset condition will be able to ensure acceptable service levels.

An early warning system will help to anticipate this change and will alert management to potential failures and problems before the actual occurrence thereof. An Early Warning System is essential for painting a [illegible] to ensure predictability. The major proviso of such a system is that users must have confidence in it. If several indicators point to the same problem the signal cannot be ignored.

Visual inspection is the present method of determining asset condition and we have become totally reliant thereon. We can never ignore the proven experience that our staff have developed over the years, but we have come to realise that things need to be done on a more scientific basis, where management tools are used to assist decision making, which will enable us to move from a reactive to a more pro-active platform.

6. SYSTEM DEVELOPMENT

The danger in todays railway business is not realising the risks in the business and not being able to manage and position oneself once risk is identified.

In all instances we have to take decisions. The manager must be able to decide whether one alternative might be more desirable than another.

With the focus on safety, the risks that Infrastructure face must be understood and managed effectively at all levels and we believe that an effective information system is essential to identify such risks which will become an indispensable tool in the organisation.

We first realised that we would have to make some dramatic changes and improvements if we were to be in control of our business. We undertook a rigorous analysis of the requirements of our clients, of the risks and uncertainties we face and initiated an information transformation of our business that continues into the future. We decided to direct our efforts towards 4th generation technology available in the information industry.

We have learned the value of a systematic evaluation of the risks facing our business. Our thrust is to minimise the fear that "Risk is not always where you expect it to be" and to be able to develop a more predictable environment where the risks in the business become more manageable. The philosophy we support is that the decisions we make to accept and tolerate risks are as important as those we make to minimise and eliminate risks.

Prior to the development of our Infrastructure Management Information System (IMIS), essential data was stored in various databases, filing systems and CAD systems. Previously even the most basic queries on asset performance were conducted by referring to several sources using up valuable time and in many instances the information was not available or unreliable. In depth analysis of asset condition was never possible because we gathered large banks of data but had no information.

In developing a new system it required a phased approach. The first phase involved the development of a single database to fix all infrastructure data, with line codes, maintenance units and asset identification numbers. This exercise required the verifying and cleaning of the present available data. This system allows the recording of actual field measurement readings, fault records, site work etc.

In phase two we embarked on a process of developing deterioration models based on present norms, standards and instructions. The exercise commenced with workshops where various decisions were made by experienced staff in terms of life expectancies of assets and asset deterioration rates. This process required the use of averages to be made with some degree of confidence as well as the development of probability distributions for each variable based on experience. To effectively develop models for the track condition, many variables need to be considered i.e. traffic tonnage, axle loads, lubrication, rail metallurgy, rail wheel interaction etc.

Infrastructure is vulnerable and can sometimes unexpectedly fail. Estimates of potential failure based on present knowledge, no matter how judgemental it may be, is always better than no estimate at all. Our worst enemy for progress is trying to achieve perfection.

This developmental phase is ongoing and will run parallel with all other developments. Prediction models will be improved over time as more information is gathered and new technology is developed.

Looking beyond our borders at Germany we see that J R West are developing a system to monitor track condition based on car vibration technology; the European rail companies have undertaken a research project to develop theoretical modelling to provide scientific theoretical background in order to enhance the prediction of the geometric deterioration of ballasted track. This emphasises the fact that we must learn from experience in other countries.

Signalling systems are by nature of high design risk free systems but for every right side failure, the risk of an accident significantly increases due to the human factor (train controller) in providing authorisation to the train driver.

The challenge does exist to use information to maximise the inherent reliability of the system.

Major advances have been made to develop statistical tools to analyse fault data and identify failure modes and facility predictions of the equipment.

Our central train control offices are also monitoring the operation of equipment, such as point machines, with the view of identifying deterioration of performance.

Signalling technology is experiencing a rapid change as microprocessors and micro-controllers which make it easier to process large volumes of data into useful information which can be transmitted by means of advanced modes of transmission. This provides increased opportunities to monitor the assets to ensure continuous high level performance. Fault diagnostic and alarm facilities in the newer generation systems, providing quicker reaction times and therefore less train delays and again lower maintenance costs.

In the Electrical discipline the asset condition assessment systems have been developed for overhead track equipment and certain traction substation equipment.

On completion of the initial assessment of the condition of all these assets the monitoring process will commence enabling historical data to be captured on which predictions of life expectancies can be verified. These models will assist management in determining the optimum point of replacement of equipment considering the condition, costs to maintain, reliability and availability.

Phase 3 of the system development involved a comprehensive risk assessment of each discipline. This has been formalised in a Safety Case which forms part of our Safe Railway Management System process. This has provided line management with a good understanding of the various risk profiles which need to be managed.

We commenced with phase 4 when we came to realise that Geographic referencing of our assets and data was emerging as a technology in meeting the changing needs of today's managers. We found that there has been an evolution of Geographical Information Systems (GIS) from a field proven data integration technology to a core organisational management tool.

Infrastructure commenced this phase with a pilot project in one of our regions. The object of the project was to create a system for immediate use by the disciplines and also prepare for a master implementation of GIS within the entire Metrorail.

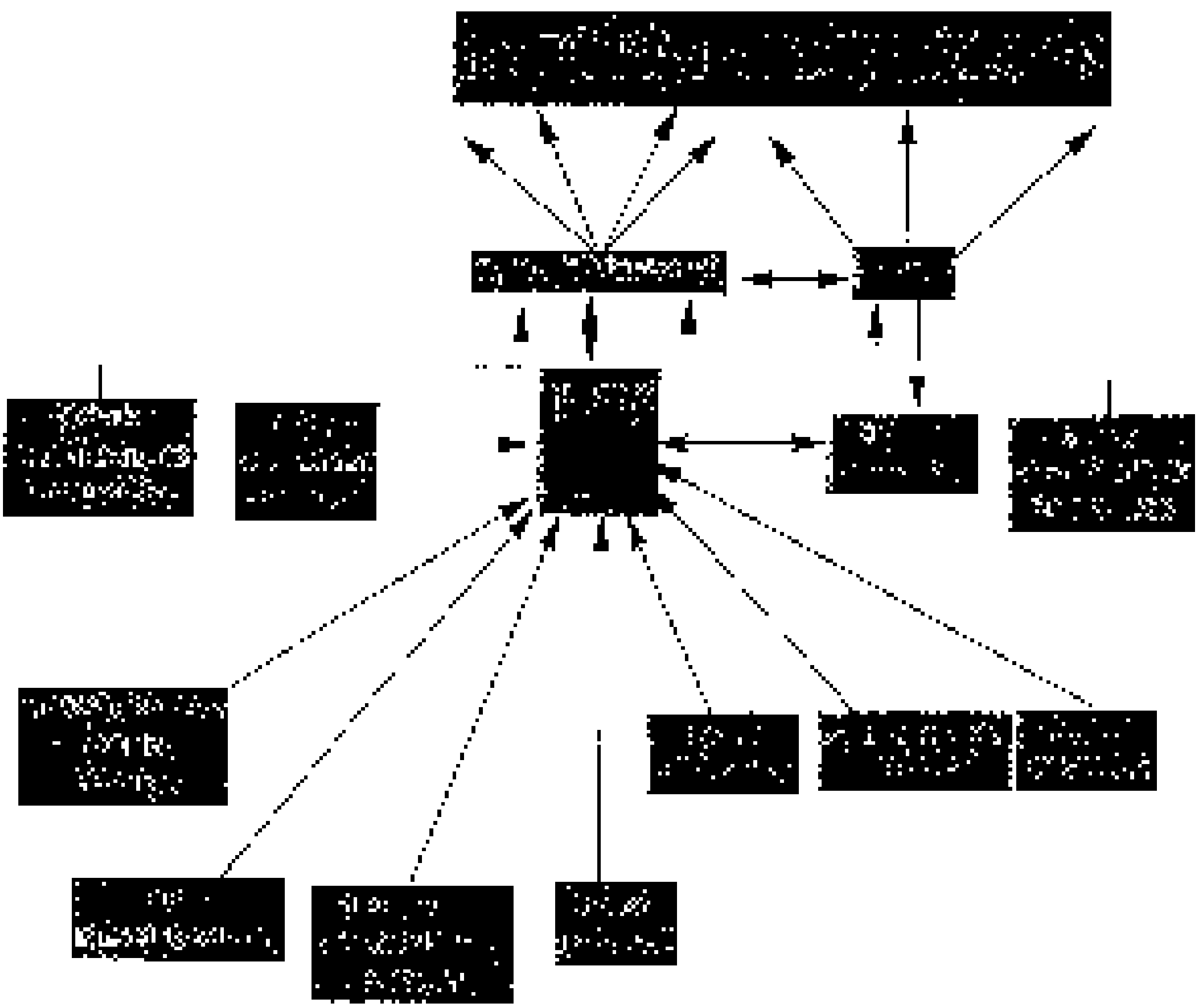
One of the key components of the pilot project was the capturing of the track, signals and electrical assets. A decision was made to capture the data on a portion of the rail network by means of GPS (Global Positioning System). The GPS mapping system provided a quick and relatively cheap method to collect and transfer physical site data to the GIS system. We further linked the GIS with our existing Databases.

The aim of the pilot project was also to introduce the technology to the staff and develop a centre of excellence which would enable Infrastructure to plan full scale GIS implementation.

The decision was taken to implement a full scale GIS for all the [illegible] assets like buildings, property and land. GPS was found to be unsuitable for the capture of large datasets and it was decided to go the route of aerial photography being the most accurate method of capturing this data. Two of the four regions have been completed and the mapping process is well advanced.

The migration of our existing database and other applications into the spatial environment, along with the integration with other data in the organisation is now the big task that lies ahead.

GIS is being designed as a corporate system and will in future service many disciplines other than Infrastructure, using a common shared database.



2. CORE BENEFITS

I have said what has arisen from the conference theme, but we will now focus on the benefits of the information system.

The resultant benefits realised from the pilot project are a potential five-fold increase in the speed of processing various enquiries on asset management such as condition reports and risk assessments. We already see major productivity improvements developing out of the system.

Using the system would allow the user to interrogate the database by way of line codes and asset codes. Once the spatial extent is established, the location and relevant details of the specific asset can then be displayed. Other details relating to this asset can be retrieved such as maintenance history, past failures, incidents, asset replacement plans etc. Our managers will now have a unique way to retrieve, view, analyse data and produce short term and long term plans to address maintenance and replacements in a more safe and low risk rail environment.

The key benefit of the system is that it enables our employees to improve communications at all levels of the hierarchy. Vertical communication as well as horizontal communication and data exchange between disciplines and departments will improve dramatically.

The manager will use the geographic system to bring together the maps and data needed to visualise not only where the line or asset is located, but also its age, tonnage carried, maintenance history, fault reporting, failure and accident statistics.

The advantage in terms of the data linkage in GIS is that all the data bases will use the same location indicators enabling staff to conduct one single search for cross functional information relating to a specific location or asset.

This cross functional information referred to is the data from our existing databases developed in phase 1 and is constantly fed with new data by our linesmen, signal maintainers and track inspectors.

We are creating an interactive data environment with numerous "relational" information which will provide a correlation between various incidents i.e. the position of track side marks in relation to the signal post, pantograph hookups in relation to the geometry of the specific track, defect occurrences in relation to traffic density (tonnage and number of trains) and asset age.

We can examine Infrastructure defects and look for tendencies which could indicate problem areas requiring attention. Typical failures / defects include the following: washaways, flooding, bush fires, contact wire wear, rail wear, rail breaks, derailments, block joint failures, ultrasonic rail defects, kickouts, electrical earthing problems, track geometric defects, landslips, mudholes, skid marks, rail corrugations, corrosion of structures, broken sleepers and fastenings, signalling equipment failures (many types) etc.

Because of the data linkages inherent in our holistic approach, someone analysing a rail can now determine the condition and extent of maintenance required. We can analyse the historical maintenance data to reveal input effort versus resultant condition and availability of infrastructure so as to optimise the maintenance operation and reduce failures.

There are many integrated maintenance operations which take place on a daily basis and the combined effect of all these operations can be visually depicted and viewed with failures or outage times to reveal relations between maintenance operations and system performance. An example of this would be: What influence does ballast cleaning and ballast tamping have on track performance? Is there a difference in track performance following grinding operations and how is this influenced by the ballast / formation condition? What part does track geometry play in system performance. What specific reasons can be identified as causing skidmarks and railbreaks? Are certain areas more prone to defects than others and are there differences in response and repair times between maintenance sections?

7.1 CORPORATE BENEFITS

- The spatial information of Infrastructure has a major benefit to Train Services and is being used for their Train Scheduling programmes. This will allow Train Services to simulate various scenarios and results in emergency situations such as derailments, occupations, power failures etc.

- We can analyse accidents / incidents / injuries in relation to pedestrian and level crossings.

- We can link train delays and cancellations to specific infrastructure problems and other operational factors.

- Tracking of historical trends of cable theft and vandalism to identify recurring problem areas can be done.

- We can link costs, passenger counts and revenue per station on a visual basis for better business management and decision making.

- Planning of intermodal transport in conjunction with geographical [illegible] from the Metropolitan authorities will be possible.

By manipulating and analysing the data within a geographical context with the decision support models discussed earlier in phase 2, Infrastructure will be able to anticipate, predict and deal proactively with maintenance requirement which will result in a more predictable service.

8 CONCLUSION

The IMIS will enable line management to make informed decisions and use information to improve processes via desktop PC's.

According to the Health and Safety regulations, organisations are compelled to take all reasonable steps to ensure compliance. We see the management process via our information systems as providing a sufficient mechanism for compliance. Management will now not only prepare for the disaster which may occur but will also be able to see the risk potential of those small everyday activities. The challenge will always remain to identify the threats which have serious consequences but low probability of occurrence.

Infrastructure will progressively implement this information technology tool in order to empower employees with information. We will constantly research new technologies such as Georeferenced Digital Video, which will dramatically reduce data collection time as compared to manual surveys. We believe that this information technology shift that we are busy with will reduce overall cycle times for a number of our operations and contribute significantly towards asset condition predictability and improved safety.

1996 CAPE TOWN

[illegible] October - 9 October 1996
The Lord Charles Hotel, Cape Town, South Africa

Paper 9627

Olaf Lingwall

Banverket:
Risk Finance and Risk Information System

CURRICULUM VITAE

Per Olof Lingwall

Per Olof Lingwall is a senior economist at Banverket. He works at the Finance department at the Head Office with matters related to budget, controlling and finance. He is responsible for the Annual report of Banverket and the various contracts regarding financial aid and loans with international organisations such as the European Investment Bank and the European Commission. He is involved in a programme of improving Banverket's cash management.

Since 1995, Per Olof Lingwall has been leader of Banverkets different risk finance programmes. He has a direct responsibility of Banverket's external and internal insurances and he also has a responsibility of the different measures of reducing the risk exposures.

He graduated from the Swedish University of Agricultural Sciences in 1988 with a Masters Degree in Science (agriculture). Before joining Banverket, he was working for the Ministry of Finance where he was responsible for the budgets for the Ministry of Foreign Affairs and the Ministry of Finance.

Risk Finance and Risk Information
At The
Swedish National Rail Administration
(Banverket)

by

Per Olof Lingwall
Swedish National Rail
(Banverket)

1. Banverket - The Swedish Model

Banverket (BV) is a Central Administrative Agency which is responsible for the operation, maintenance and investments of the Swedish State's track installations. The activities of BV is mainly financed by annual government grants.

BV was formed in 1988 as a result of a new Transportation Policy Decision. This policy stipulated that the previous state railway authority, SJ, should be turned into a train operator strictly acting on commercial basis and an infrastructure manager (BV) acting on socio-economic basis should be established.

Today BV is managing some 10 000 kilometres of railways of which 6 744 kilometres consist of trunk railways. Approximately 74 per cent of the total network is electrified and roughly 13 per cent has double track standard. A track utilisation agreement between BV regulates the use of the Swedish State's track installations and the responsibility for this utilisation

The introduction of the new railway policy also contained a programme of upgrading the entire network. New railway lines have been opened, the capacity has increased by the construction of double tracks and heavy reinvestment measures has taken place. During 1995 BV has spent about 10 MSEK on investments.

2. The Risk Situation for BV as an Infrastructure Manager

2.1 Legal Situation - "Strict Responsibility"

As an infrastructure manager BV has the legal responsibility for the tracks and the related equipment. According to Swedish law the responsibility is "strict", i.e. BV has an obligation to compensate for incurred damages even when the damage is caused by the train operator. BV is authorised to handle the different claims concerning casualty (property and liability) and personal injury. BV yearly pays expenses of approximately _______ MSEK.

According to an agreement between BV and SJ, claims for damage from rail passengers and freight customers are regulated by SJ. Examples of compensation for damage regulated by BV are :

- dogs, cattle and reindeers killed or injured by the train

- persons killed or injured by an approaching train
- persons killed or injured by the catenary

2.2 Track Utilisation Agreement between BV and SJ

A different situation occurs in the relations between BV and the main train operator, SJ. According to the above mentioned track utilisation agreement BV is compensated for damages on the track installations caused by SJ. Consequently BV is compensating SJ if the track installations has damaged the rolling stock. Damages below 20 000 SEK is not compensated. The agreement covers the traditional traffic accident risks in the rail sector as train leaving the track, collision between two trains etc.
Yearly about ________damages are settled by a working group consisting of representatives from BV and SJ. During 1993 - 1995 BV's compensations to SJ was some ___ MSEK. SJ's compensations to BV amounted to________MSEK

2.3 Level Crossings

Collisions between a train and a motor vehicle at a level crossing represent the most common rail accidents in Sweden expressed in killed persons. However, the number of accidents and killed persons have dramatically decreased during the last five year period which partly is explained by BV's measures of abolishing level crossings and the construction of level separated crossings. During 1995 some 49 accidents incurred and 8 persons were killed in level crossing accidents.
Claims regulations concerning level crossing accidents are somewhat different from the procedures mentioned above. Compensations are paid by the road vehicle's insurance. If it is proved that the accident is caused by failure in the track installations (which rarely happens), the Insurance Company may claim BV for compensation.

2.4 Other Risks

BV has set up a joint stock company SVEDAB, in co-operation with the Swedish National Road Administration (VV). The company is responsible of carrying out some construction works connected to the building of the fixed Öresund Link. Even if the

construction works will be financed by user's fee, the financial risks are considerable.
Also concerning the ongoing construction of a new air link to Arlanda airport, BV has in co-operation with the Swedish Civil Aviation Administration (LFV) formed a joint stock company, A-banan AB. The project, partly financed by private capital, represents a financial risk because of the uncertainties beyond BV control.
Due to the existing financial risks mentioned above the companies are requested to report any changes for it's owners which may increase the risk exposure.

3. Financing of Risks and Damage

3.1 New Government Directives

Traditionally financing of risks and damage have played a minor role in risk management for the central agencies in Sweden. But since the beginning of 1990 the Swedish Government has decentralised a considerable financial responsibility from the central ministries to the central agencies. In scope of this development a study was conducted during 1993-1994 concerning risk management. The main findings were :

- expenditures for highly frequent smaller damages were considered (and financed) as working expenses

- expenditures for bigger damages were usually covered by additional government grants due to the prohibition of external non-government insurance

- limited knowledge concerning risks and risk exposures

- unreliable statistic/information concerning occurred damages

In order to improve the risk management the agencies were instructed by the Ministry of Finance to analyse their risk exposures, establish routines for risk information and to perform risk analyses. The prohibition for commercial insurance still remains but the government has introduced a new form of insurance solely open for state agencies.

3.2 Risk Finance for BV

The findings concerning risk management in the above mentioned study were in several points also eligible for BV. Even if the railway sector in Sweden during the last years have been saved from bigger rail accidents, a big and costly rail accident seriously could harm BV operations.
During 1996 BV has signed an insurance agreement with the Government covering claims for each damage in the range between 15 MSEK and 300 MSEK. The excess level was chosen because of the very few number of damages exceeding 15 MSEK. Consequently, damages below 15 MSEK are financed by ordinary budget allocations.
The Industrial Division of BV which is a part of BV's production units, is organised as a result unit with profitability requirements. In order to create solutions of risk finance comparable of traditional business companies, an insurance agreement has been established between the division and the Department of Finance at the Head Office

4. Risk Information

Compared with other state agencies BV has well established routines for reporting faults at the track installations which can cause rail accidents. BV also pays lots of effort of offering the train operators a reliable rail system reducing the number of train delays caused by the rail infrastructure.
The very high new and reinvestment level during the last years has allowed BV to renew the track installations. Bridges, interlockings, transformers are examples of different installations important from risk management view which have been modernised.

The use of risk analysis is today a standard activity when BV is performing studies for bigger new and reinvestment measures. However the objective of those risk analysis is BV's responsibility to provide a rail infrastructure system on socio-economic terms. Still BV needs to improve its ability to perform risk analysis in various fields, below some examples .

- legal risks
  contracting and consulting responsibility, liability due to the high level of works contracted out etc.

- Operational risks
  higher reliability requested by the train operators, higher government standards for environment etc.

- Financial risks (liquidity, credits, borrowing)

It is important to note that the risk analysis represents a first important step of risk management. This step should be followed by different measures in order to prevent damages and to keep occurred damages within the bounds. The final step of the risk management is the risk finance.

5. BV Further and Future Ambitions

5.1 New Conditions

During the summer of 1995 two important steps were taken towards a continuation of the Swedish railway reform. First, the rail infrastructure was partly opened up for other train operators than SJ. Second, the responsibility of traffic operation and track allocation was transferred from SJ to an independent unit within BV.
The entrance of new train operators on the Swedish rail tracks will introduce new risk exposures for BV. Track utilisation agreements regulating among other things damage compensation must be established. The new operators must also have a financial strength to organise a satisfying risk finance. An example of a new operator is MTAB which is owned by the mining company LKAB (51%), NSB and SJ (49%). The new operator will operate the mining trains on the Iron Ore Line from the Kiruna Mine to the Ports of Luleå and Narvik.

Traffic operation and track allocation give BV a much clearer role to play concerning the operation of the rail infrastructure. On the other hand, the responsibility for the track installation and its operation will also be deepened which also will affect the risk management. The new situation must be carefully analysed by BV.

5.2 New BV Organisation

BV is currently reorganising in order to match the new requirements from the Government. The new organisation will consist of a Head

Office, a traffic and infrastructure manager and a producer. The organisational work will be completed during 1997.

An important issue for the new organisation is to establish a client-server relation between the infrastructure manager and the producer. For the manager which will be responsible for the track installations risk management must be an important tool in order to achieve reliable installations.

Also for the producer which will be run as a traditional business company, risk management will be top priority. Bad risk management may cause high compensations to be paid to the infrastructure manager and consequently badly affect the profitability.

The overall risk finance of the reorganised BV will be the responsibility of the Financial Department at the Head Office. In order to create better incentives to lower the risk exposures and the damage compensations, internal insurance will be established.

5.3 Conclusions

In accordance of the development described above, Banverket as one of the biggest Government Agencies in Sweden, has the ambition to continue and to improve the risk management.

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Jos Hendricks

Risk Assessment in the Railned Safety Management System

Publisher
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CURRICULUM VITAE

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Various positions in management and project management in the Infrastructure Division of the Nederlands Railways NS (research, design and installation in the field of telecommunication-and train control-systems).

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RISK ASSESSMENT

in the RAILNED Safety Management System

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International Railway Safety Conference 1996
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Republic of South Africa

Contents

1 Introduction

The Netherlands Railways (Nederlandse Spoorwegen, NS) is going through a period of major changes. At the beginning of 1996 the final phase of one of the Netherlands' greatest privatisation operations was completed. As an autonomous company, the NS is now able to move along the road towards a market-oriented organisation that has to compete with other carriers. The first new carrier began carrying passengers in August. Others have already shown an interest in rail transport. These developments have major consequences for the management of safety in the rail transport system.

1.1 Deregulation of rail transportation in the Netherlands

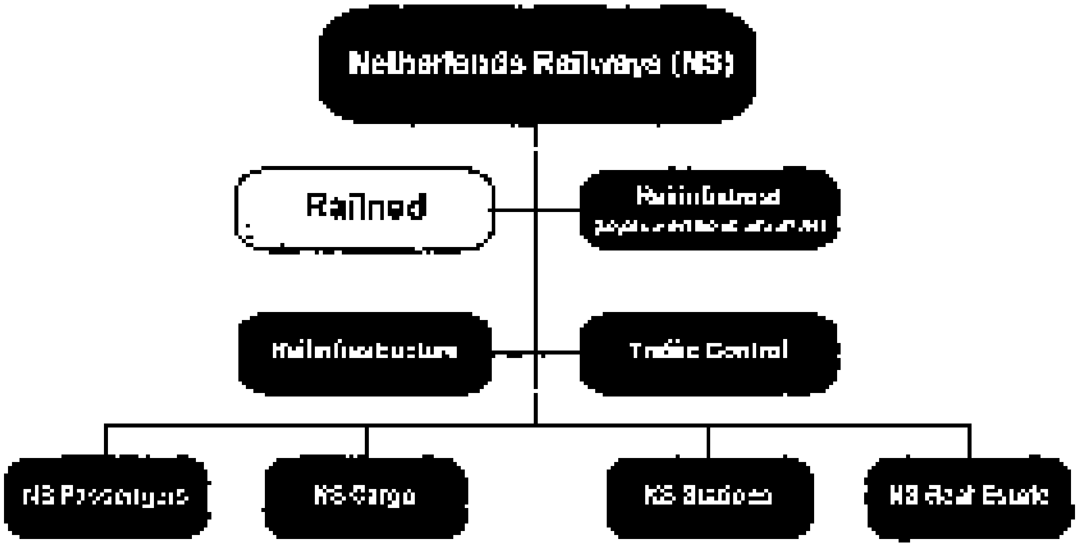
In [illegible], a committee gave advice to the government on the privatisation of the NS in the context of the deregulation of rail transportation wanted by the EC. With less subsidy from the government, a privatised NS would be able to achieve a doubling of the number of passengers. In [illegible] the government approved the separation of the management of the infrastructure and commercial operation as stated in EC directive 91/440. The formal separation between infrastructure and operation became reality in [illegible].

The contribution of central government to the NS is being cut back. In the view of the NS the unprofitable lines must be paid for by regional or local government or new forms of operation have to be considered when the flow of subsidy is ended in [illegible]. It will then no longer be possible to take for granted that the NS will take care of the rail transport. In the meantime, many candidates have already applied to the government. This has led to the first competitor on the railway network, which has operated a passenger service from Amsterdam to the coast in North Holland since August [illegible]. This line had been closed by the NS in [illegible].

1.2 NS organisation

The organisation of the NS was radically changed in [illegible]: a separation into a commercial sector and a task sector. The task sector is financed by central government and undertakes tasks for central government.

NS organisational structure



There are three departments in the task sector

Rail Infrastructure
Handles the laying and maintenance of the Dutch rail infrastructure

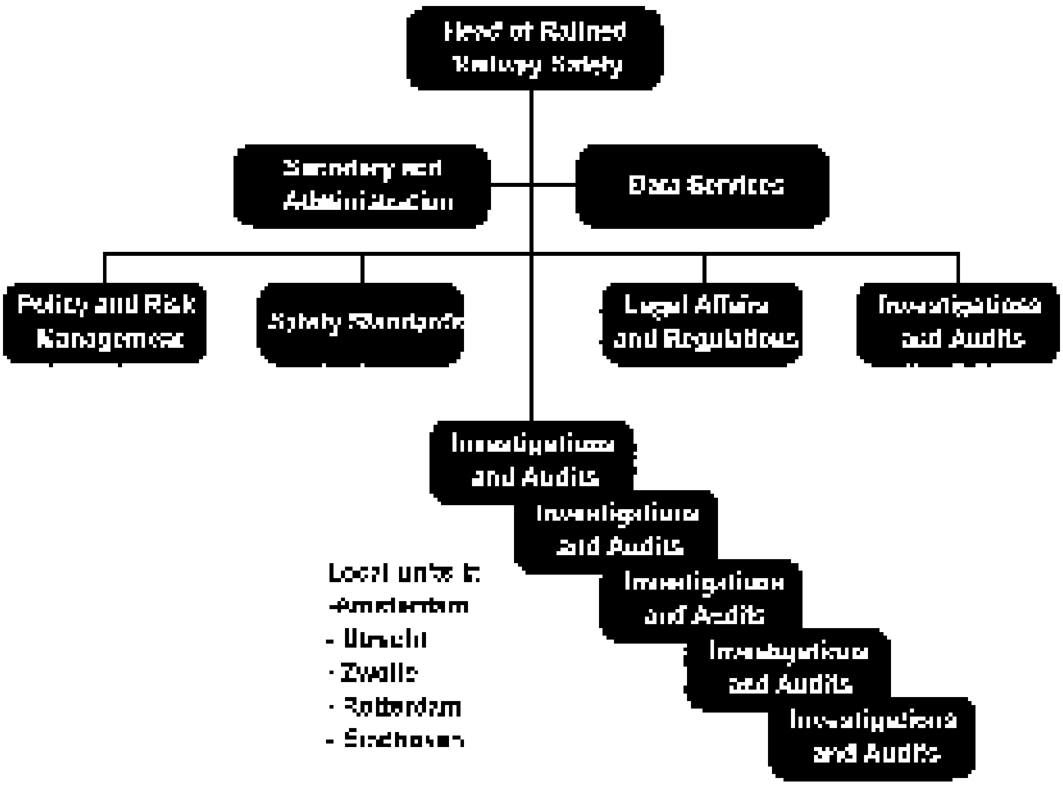
Traffic Control
Handles the short term allocation of the infrastructure and is responsible for rail traffic management

Railned
Organisation for capacity management (allocation of capacity and development of new infrastructure) and railway safety

1.2 Activities of Railned Railway Safety

- drafting of policy, regulations and specifications in the area of railway safety
  advising the Minister of Transport and Water on railway safety and legislation
- drafting of safety legislation
  undertaking of risk analyses and drafting of integrated safety plans in the development of new infrastructure, new procedures and new techniques
  undertaking of inspections and audits
- undertaking of investigations into accidents and incidents
  checking whether new participants in rail transport meet the requirements for capacity organisation and ensuring safety
  certification of rolling stock maintenance companies, Health and Safety services and examination institutes

Organisational diagram of Railned Railway Safety



1.4 Key statistics for 1995

The Netherlands

- population: 15.5 million
- inhabitants per km²: 455
- public transport passengers per year: bus/tram/metro: 710 million
  railways: 310 million
  air: 25.5 million
- number of motor vehicles: 6 million

Netherlands Railways

- staff: 26,730
  passenger kilometres: 14 billion
- passenger train kilometres: 110 million
  freight train kilometres: 3.1 million
- network length: 2,739 km
  automatic train protection ATP: 80%
- passengers per day: 900,000
  trains per day: 4,500

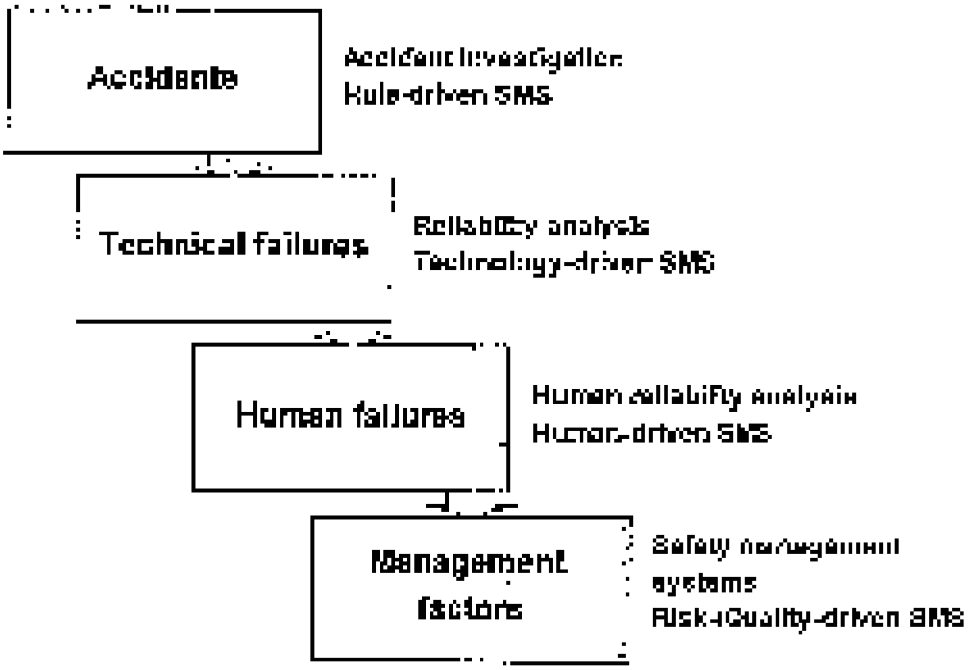
2 The Railned SMS approach

The Railned SMS model is a risk-based management system. This approach gained a particularly great impetus after a number of major railway accidents in 1962 and has been further developed by Railned Railway Safety. The mission of Railned Railway Safety is the prevention and limitation of injury and loss arising from disruptions in the rail transport system. Injury relates to passengers, staff and third parties. Loss relates to material loss, damage to the environment, loss of continuity and loss of the goodwill of the public and customers. In the current phase of development of the SMS, the main attention is on injury, with only limited attention to loss.

2.1 From management through accidents to continual improvement

For a great many years, accidents were virtually the only cause of improvements in safety. Lessons from accident investigations were usually translated into stricter regulations for the executives. New technical possibilities allowed better opportunities for ensuring the safety of railway transport. This process was more technology-driven than risk-driven. In the eighties, greater attention was paid to the role of human error. From about 1990 onwards, ensuring safety at the NS has come to be viewed as a matter of management, through which the principle of continual improvement made its appearance. Concern for safety thus became a part of the overall management activity [illegible] the left part of the picture.

Chronological development of SMS at the NS:



2.2 Continual improvement

A path of continual improvement is being sought for railway safety. The actual situation must be accurately known for this. Proper registration of accidents and incidents is an absolute prerequisite. At Railned, all the information from investigations into accidents and incidents from 1981 onwards (about 5,000) have been stored in a database. All irregularities in rail traffic (about 50,000 a year) have been included in a database since 1995, and are updated each month.

2.3 Risk-based SMS

The Railned SMS assumes a risk based approach. In this risk can be regarded as the probability of injury and/or loss. In the current phase of development the main focus of attention is on injury.

2.4 Structural, long-term safety

All the measures to be taken to improve railway safety must be structural and long term. They must also have an effect in the longer run. An active approach is therefore the main thrust of railway safety policy:

- the prevention of the occurrence of accidents and a reduction in the seriousness of those accidents that do occur are of primary concern;
- a proactive approach to railway safety is required by considering railway safety at as early a stage as possible and in all areas (exploratory studies, project development);
- an emphasis on measures that remain effective, in both infrastructural and non-infrastructural facilities.

2.5 ALARP

The ALARP (As Low As Reasonably Practicable) principle applies in the development of measures. This means that the effectiveness of measures is weighed against their cost. Acceptability and alternatives also play a part in the assessment.

The ALARP principle continues to apply even when the goals have been or are on the verge of being achieved. Simple and/or inexpensive measures with a positive effect on safety may never be neglected.

2.6 Stand still

No additional risk may arise when there are major changes in the infrastructure, process (new/modified), rolling stock or organisation (stand-still principle). This also applies when the targets might already have been met. The safety objectives must, however, still be observed. This may mean that applying the standstill principle is not enough and that compensation alone may not be sufficient.

2.7 Exchange of risks

Risks may not in principle be exchanged, even when this means that the risk would remain within the objectives. It is thus not permitted to accept a higher group risk as a result of collisions of passenger trains for a reduction in individual risks in the boarding and disembarking of passengers, for example.

2.8 Minimum set of safety activities

From the principle of "best practice", the activities that must as a minimum be present according to a proper SMS have been examined. For Railned these are:

- structure of safety organisation
- safety in design
- contractor safety
- safety training of staff and management
- operations
- safety measures and procedures
- maintenance
- fighting disasters

- accident reporting and analysis
- inspections
- internal audits

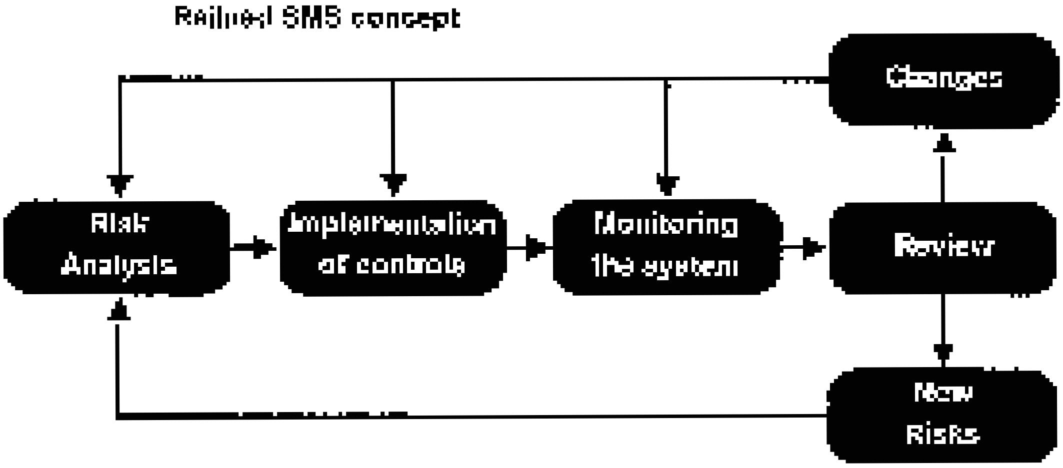
2.9 All aspects: management circle

For each safety aspect a management circle is applied: Planning (plans, measurable objectives), Organisation (activities, responsibilities), Implementation (work schedules, working instructions, procedures) and Checking (measurements, evaluations).

2.10 Quality of underlying organisation processes

The quality of the underlying processes must lead to a long-term effect:
- safety methods and techniques are used that are appropriate to the nature and extent of the risks. A specific QRA is being developed by Railned, tailored to rail transport situations and the databases available at Railned. Methods are in development for accident investigation, audit and inspection that are appropriate to the rail transport system and that yield 'trendable' management data not only for the whole rail transport system but also for each company. (TRIPOD based method)
- the way in which safety management is implemented takes account of the prevailing company culture.
- particular attention is paid to interfaces. Due to the privatisation of the NS and the advent of other carriers, this aspect has increased in importance.
- safety management is consistent.

3 Railned SMS concept



3.1 Risk analysis

Risk is a function of probability and effect. Risk analysis is therefore an analysis of probabilities and effects. The determination of standards and criteria which the risk must meet also form part of risk analysis along with the development of measures and the assessment of measures in terms of cost and benefit to safety.

Risk assessment is regarded as a part of risk analysis and comprises:
- identification of the undesired events (hazards)
- determination of the probability of occurrence of the undesired events
- determination of the probability of occurrence of effects
- determination of the probability of the consequences of the effect, given the effect
- determination of the percentage probability of the risk
  determination of the risk
- statement of criteria which the risk must meet
  assessment of the risk with regard to the criteria.

When there is insufficient data to be able to determine the probabilities, a qualitative analysis is performed following the same steps in which scenarios are used or situations and solutions are compared to each other.

3.2 Execution of measures

The measures relate to all parts of the organisation:
- structure of safety organisation
  safety in design
- contractor safety
- safety training of staff and management
  operations
- safety measures and procedures
  maintenance
- fighting disasters
- accident reporting and analysis
  inspections and internal audits

3.3 Measurement of safety

The safety of the overall rail transport system is measured by Railned Railway Safety in all components involved:
Reactive: accident/incident investigations and the consideration of safety statistics.
Proactive: undertaking of inspections, audits and workplace visits.

3.4 Review

The review's primary purpose is to promote the continual improvement of the SMS by:
- monitoring the undertaking of measures
- monitoring the undertaking of actions as a result of audits, inspections and investigations into accidents/incidents
- identification of changes in legislation
- analysis proposals for the Transport Accident Board and Railway Inspectorate
- statements of new objectives (Railned or national government)
- research into the actual effect of measures undertaken
- identification of new risks

3.5 Adjustments

The results of the review lead to adjustments in the SMS or to a fresh run-through of the steps in the SMS. This can concern any preceding element. Thus a newly identified risk may lead to changes in responsibilities of organisations and to changes in the audit system. Should higher safety objectives be set by the national government, the current risks would have to be compared anew with these new standards.

3.6 New risks

There are many causes of new risks. The full SMS is run through and adjustments carried out in the SMS for all these risks. Examples of current new risks at Railned include:
- increased speed on existing infrastructure from 140 to 160 km/h
- the laying of the High Speed Line HSL
- new tunnels
- new freight line on Betuwe Route
- higher train frequency on existing track
- new carriers
- introduction of 25 kV overhead power lines
- changes in conduct of carriers
- introduction of new rolling stock
- different organisation
- changes in infrastructure

4 Safety planning

The first Railway Safety Strategic Policy Plan for the whole of the NS was drafted in 1995 by Railned Railway Safety. This policy plan was by its nature a plan of approach. Concrete safety objectives were indicated only in a limited way. This was due in particular to the lack of sufficient insight into the existing situation. A comparison with other railways and departments was therefore not possible. In addition, there were no objectives or initiatives from central government.

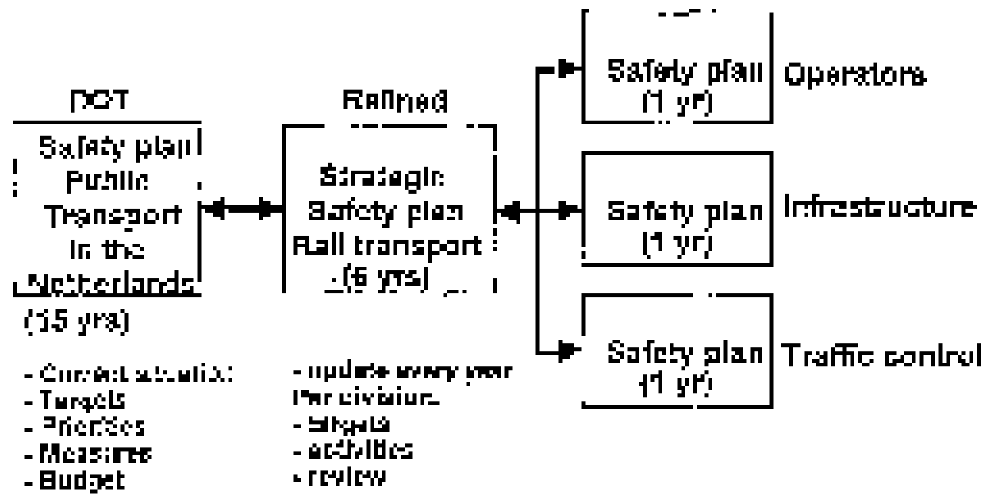
A great deal of attention was paid in the measures aimed at the development of a policy planning document on Railway Safety by the government. Railned Railway Safety provided input for this. It is expected that the plan will be completed in 1996. In the meantime, a great deal of insight has come about concerning the desired objectives for the various safety aspects through analysis of the current situation and through comparison with other railways and departments. The provisionally drafted objectives have been included in the Railway Safety Strategic Policy Plan 1997-2001. The feasibility and achievability of the objectives is still to be put to the test. This could lead to readjustment of the objectives.

The activities to be undertaken in the period 1997-2001 have also been set down. Many activities are the result of safety studies performed for national government in the context of the Rail Transport Policy Plan. Some examples of these are: Further analysis and refinement of measures to improve safety of shunting and related functions, increased safety of passengers when embarking and disembarking trains and improved registration of cases of injury to passengers and staff.

The policy plan is published each year on a rolling basis. The plan gives an overview of the accident statistics of the previous year and a review of the progress of safety activities in that year. In year n the plan covers the years n+1 to n+5. This means that the annual plans to be produced by the departments can be better tuned to the plan of Railned which covers a number of years.

Each carrier, the infrastructure manager and capacity management are obliged to produce an Annual Railway Safety Plan which contains the objectives and specific safety activities to achieve these objectives. The Strategic Policy Plan of Railned gives direction to this. In addition, each company division is obliged to produce an annual report in the first quarter which includes the safety achieved and progress concerning the activities stated in the Annual Plan.

Diagram of Policy Plans and Annual Plans



5 Risk assessment

In order for the government and Railned to formulate safety standards it was considered first to have a proper view of the existing situation. A risk assessment was therefore undertaken for each safety aspect.

5.1 Safety aspects

The following aspects are distinguished:

Passenger safety
- the probability of injury to passengers in the train due to collisions, crashes, derailments, release of hazardous materials, fire and explosions;
- probability of injury to passengers outside the train when embarking or disembarking, due to collisions to platforms and [illegible], and due to personal accidents on stairs and escalators, in tunnels and the station concourse in so far as these relate to the function of changing trains.

Staff safety
- probability of injury when working on the infrastructure to company staff and staff of contractors due to collisions, electrocution, the release of hazardous materials and personal accidents;
- probability of injury when working in the 'on-board process' (drivers and conductors) and 'side process' (shunters, wagon masters, repair technicians, cleaning staff, third parties, etc.) due to collisions, derailments, release of hazardous materials, fire, electrocution, explosions and due to personal accidents such as when embarking and disembarking.

Safety of level-crossing traffic
- probability of injury or damage to level-crossing traffic due to collision with rail traffic.

Safety of crossing waterway traffic
- probability of injury or damage due to collisions with rail bridges and due to electrocution.

Safety of trespassers
- probability of injury to people who cross the tracks at places other than level crossings or walk along the track and children playing on the track, due to collision with rail traffic;
- suicides;
- train surfers.

External safety
- probability of injury to those living in the vicinity and people close to the track due to the release of hazardous materials, coming into contact with cargo, loose train parts or derailed rolling stock.

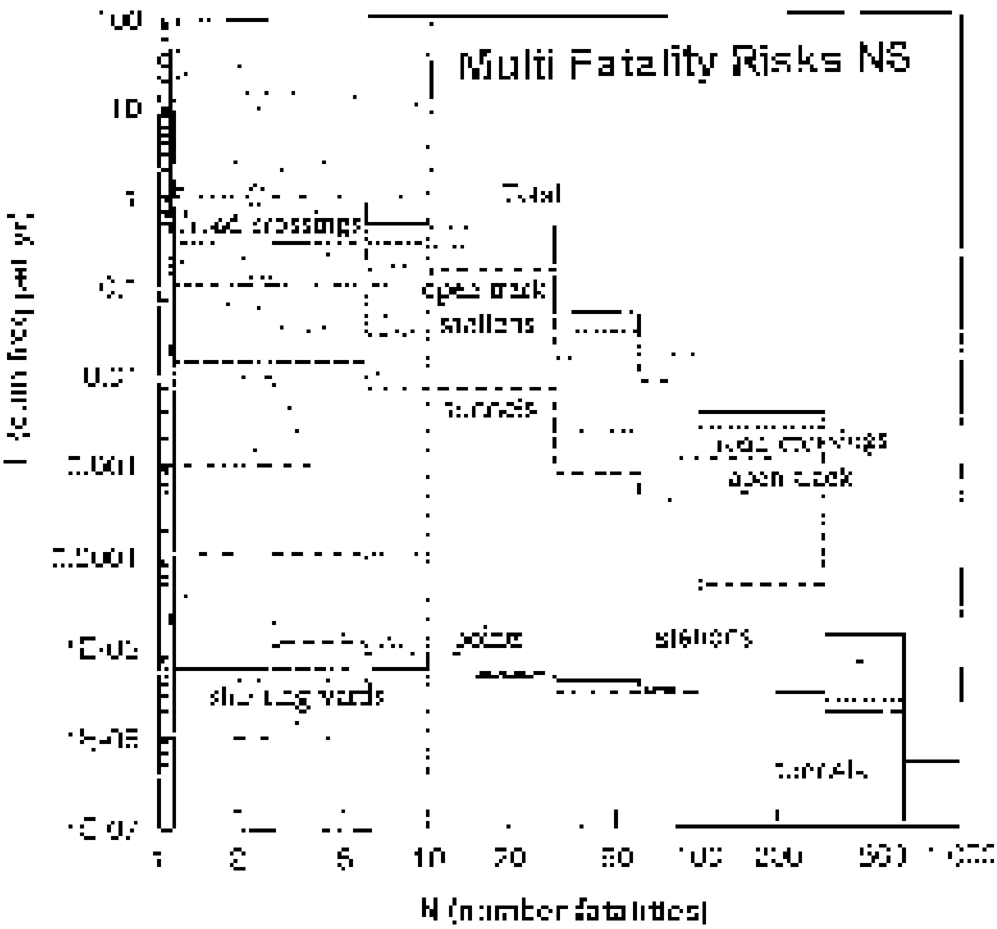
5.2 Existing situation for each safety aspect

An analysis was made of the existing situation for each safety aspect. All fatal injuries from 1991 to 1996 were known as well as non-fatal injury cases from 1996 onwards. There was no single clear source available to determine the existing situation. Data is recorded at various authorities. The available sources were thus analysed and a new overview of all cases of injury compiled.

In order to be able to track safety properly in the future, it is important at least to include all cases of injury in a single database. For this it is necessary for all cases to be recorded in an unambiguous manner at a single location. From the information currently available, it is not always possible to depends what the seriousness, the cause, or the nature of the injury was. The cases of fatal injury are known virtually completely, but information for most safety aspects on the basis of non-fatal injury is only available to a limited extent from [illegible] networks.

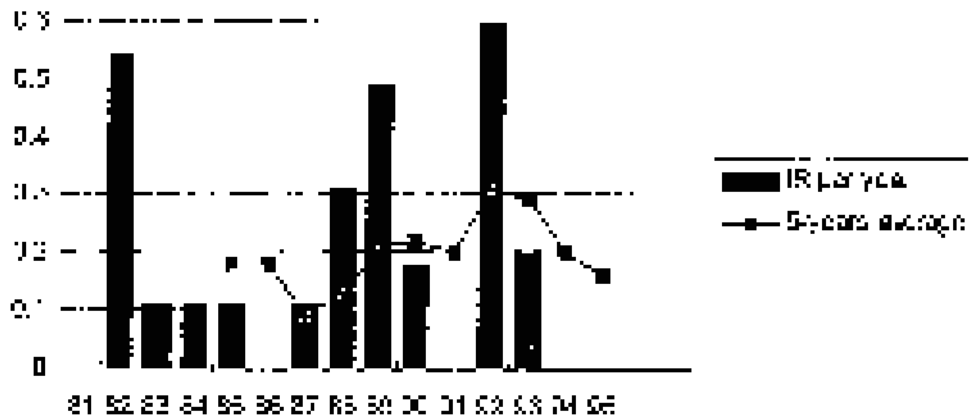
Measures of risk
When determining the existing situation for each safety aspect, Individual Risks (IR) or Collective Risks (CR) are recorded. IR is the probability that someone in a particular activity will sustain fatal injury in one year. If the term IR is used, this refers to the probability that someone will be seriously injured in an activity in one year. "Seriously injured" means [illegible] for admission and treatment in a hospital. The CR of an activity is the total number of fatalities in a year for the activity. A measurement method for Group Risks and a tool for calculating new systems is still under development. The GR of an activity is the [illegible] probability (F) [illegible] and the number of fatalities (N) of possible accidents for that activity during one year for a particular group, expressed as an FN curve. On the basis of various safety studies, an FN curve was produced for the whole rail transport system [illegible]. Due to the lack of sufficient accident history, the curve was produced on the basis of expert opinion.

FN-curve of group risk for passengers, level-crossing traffic and external safety:



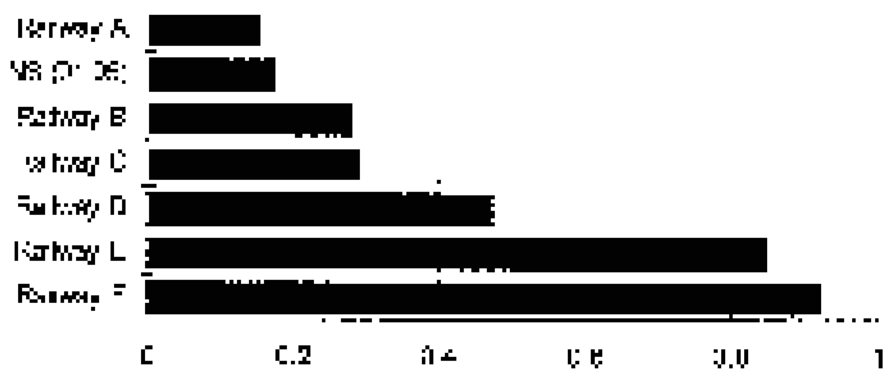
Passenger safety
Passenger safety is shown as Individual Risk (IR), expressed as the probability of fatality per annum per billion passenger kilometres. The current IR level is 0.17. The probability of serious injury (IR) is approximately [illegible]. About 40% of the risk relates to accidents to passengers when embarking and disembarking. In comparison with other railways, the IR is low in Europe. In comparison with travel by road in the Netherlands, train travel is approx. 25 times safer.

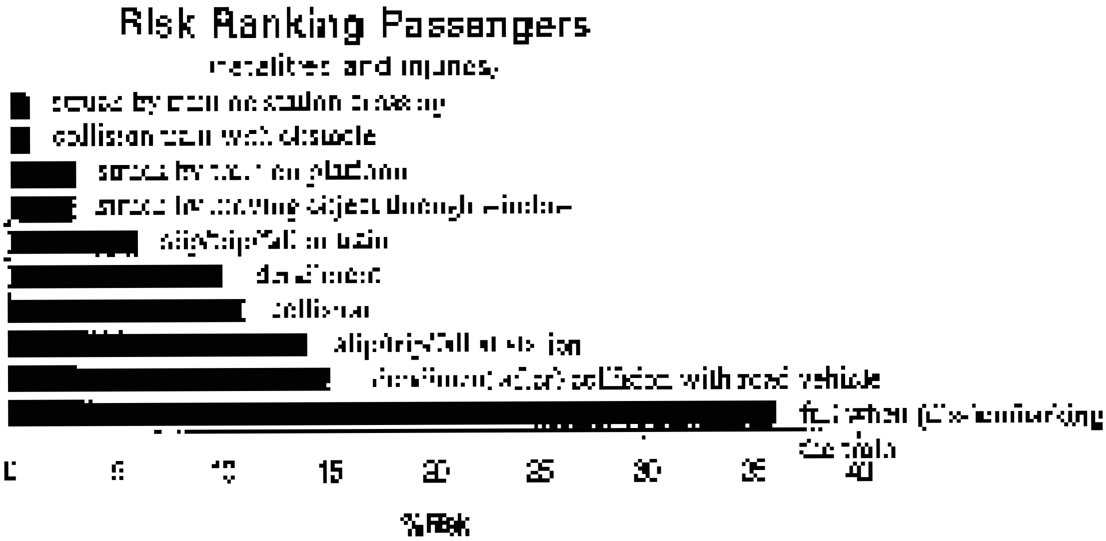
Individual Risk passengers per billion Passengerkilometers



A comparison with the [illegible] IR data of other railways indicates that the IR for passengers in the Netherlands is low.

Comparision IR Passengers between Railways

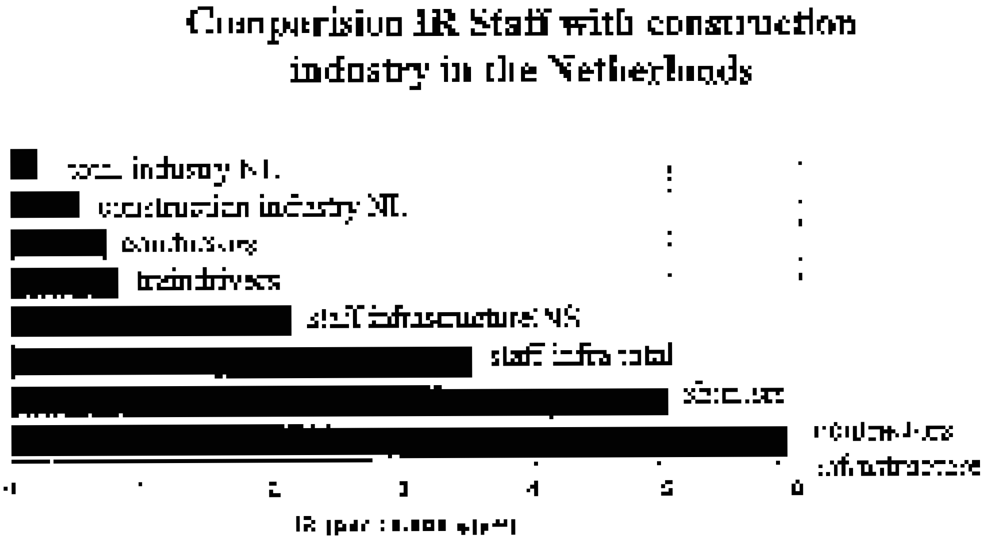




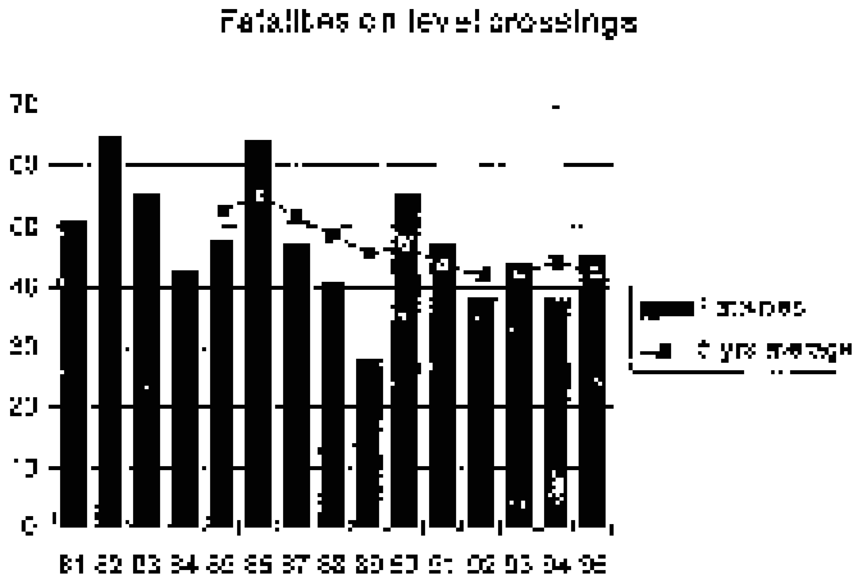
Staff safety

Staff safety is likewise expressed in terms of Individual Risk (IR). Unlike the case of passengers, however, this concerns the probability of fatality per annum per 10,000 staff. The IR is highly dependent on the type of activity. A distinction is therefore made between types of activity. In addition, only those members of staff at NS are included in the risk computations.

Working on rail infrastructure and shunting activities carry a high risk. The graph below shows this by means of a comparison with the construction industry and with the whole of industry in the Netherlands. The NS figures are based on a 10-year progressive average in view of the small group size for each type of activity and the low numbers of fatalities in absolute terms. A focus for attention for the future is the determination of the number of people at risk for each type of activity.

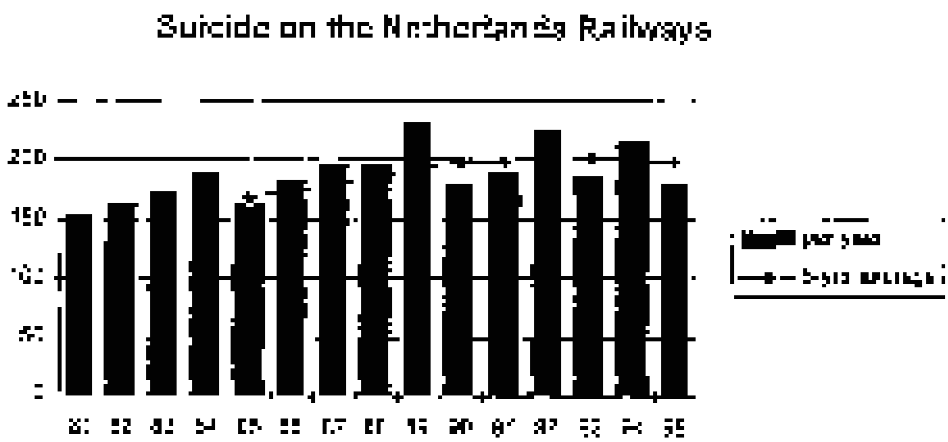


Safety of [illegible] users
The subject of level crossing safety is one of the focuses of attention in the first Transport Safety Policy Plan drafted by central government. Each year there are an average of 48 fatalities. In comparison with other countries, this is a high number.



Safety of [illegible] train [illegible]
In the period from 1981-1995 only one incident of injury was encountered. There are no indications that there might be a higher level of risk in the future.

Safety of trespassers
In the survey of trespassers, a distinction is made between suicide and other trespassers. The collective risk for each of these groups is:
- suicide: CR = [illegible]
- other: CR = [illegible]



External safety
For this a distinction is made between risks as a result of the release of hazardous materials and risks arising from the use of trade-hazard parts or due to coming into contact with derailed trains. In the last 10 years there have been no accidents in which those living nearby came into contact with released hazardous materials: IR = 0.0.
In this period there was one incident in which a derailed train led to a fatal injury to a person living in the vicinity. The CR (averaged over 10 years) CR = 0.1.

5.3 Standards and objectives

The setting of standards and objectives for each safety aspect is done through central government and these are included in the Rail Transport Safety Policy Plan of the government. The desired objectives are set provisionally. The objectives for level-crossing related safety and for the safety of trespassers (suicide) in particular still have to be checked for financial achievability. Technical achievability will also play a part in the measures to be selected.

A measure of risk is set for each safety aspect and classification, a maximum Maximum Permissible Risk, short-term objectives (1998 and/or 2000) and a long-term target value (2010). Depending on the safety aspect, further classification is made between Individual Risk (IR) and IR[T] and Collective Risk (CR).

5.3.1 *Measure of risk*
The measure of risk is the scale by which or the unit in which the risk is expressed. This can be a different meaning for each safety aspect.

5.3.2 *Maximum Permissible Risk MPR*
The MPR is regarded as the upper limit of the acceptable risk. This means that should the MPR standard not be achieved, the activity should in principle be stopped. When the MPR is not met, a cost benefit assessment is therefore only appropriate in the sense of cost optimisation. Such a standard may not be feasible or relevant for all safety aspects.

5.3.3 *Short-term objective*
The short-term objective indicates the level of safety that must be reached or maintained by 1998 or 2000.

5.3.4 *Long-term target value*
The level of safety that is sought in the longer term (the year 2010).

5.3.5 *Standards and objectives for each safety aspect*

Passenger safety
Up to the year 2000 the existing safety level must at least be maintained at IR = 0.2. Additional risks due to changes in infrastructure, timetable, procedures, organisation etc. must therefore be compensated for. For infrastructure that is new or radically changed, account must be taken of an IR = 0.15 to be reached by 2010.

By 2000 the IR[T] must be reduced by 10% in comparison to the current situation.

Since approximately 40% of the cases of injury to passengers occur when embarking and disembarking, specifically for the embarking/disembarking risk a reduction must be achieved of 10% in relation to the current level in the proportion of IR[T] by 1998.

Staff safety
In the year 2000 the IR of all groups of staff "at risk" does not exceed 1.0; the objective for 2000 is IR = 0.5. For 2010 a target value of IR = 0.25 is being maintained.

In order in the very short term to be able to proceed from a directly measurable control standard, in 1998 the number of accidents for each group of staff at risk must not be higher than AO[illegible] 150.

where IF* is equal to the number of cases of category 2+3 absenteeism, i.e. no more than 13 accidents with at least one day off work per 100 staff.

Safety of level crossing traffic
The CR due to collisions on level-crossings should have fallen by 25% to CR = 39.3 in the year 2000. The reference point is 1995 (average 1991-1995), CR = 52.4. A further reduction is being sought by 2010 of another 25% to CR = 26.2. This approach is in agreement with that of the operator to safety of road traffic as stated in the Traffic Safety Plan. For major changes in infrastructure and/or ATB measures, an improvement to a system level will receive priority over an improvement to individual level crossings.

Safety of trespassers
A distinction is made between trespassers and suicides. The stand-still principle applies to trespassers: the current safety must at least be maintained at CR = 1.0.
For suicide, the short-term objective is a lowering of the existing risk level by 25% to CR = 150. A reduction by 50% to CR = 100 is aimed for by the year 2010.

External safety
The objectives for this are being set in a study by central government and Railned/NS.

Overview of current situation, standards and objectives

Nature of risk	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Current situation	IF = 0.17 IF* = 13	infra: 3.5 shunting: 5.0 drivers: 0.8 hazard: 0.7	CR = 52.4 (1991-95)	suicide: CR = 200 other: CR = 1.0	0.0	Haz. mat.: IF = 0.0 other: CR = 0.1
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Objective 1998	IF = 0.20 Max. 10 fatally injured embarking/ disembarking -10% of ave. 91-95	80/100				
Objective 2000	IF = 0.29 IF* = 10	IF = 4.5	CR = 39.3 (-25%)	suicide: CR = 150 other: CR = 1.0	n.a.	still to be developed (PAGO)
Target value 2010	IF = 0.15 IF* = 7.5	IF = 0.26	CR = 26.2 (-50%)	suicide: CR = 100 other: CR = 1.0	n.a.	still to be developed (PAGO)

*) = Number of accidents with at least one day off work per 100 staff.

6 Conclusions

The development of a complete and properly functioning SMS of Railned is very well advanced. The development of methods related to the rail transport system [illegible] and its accident investigation is in full swing. The first programmed safety registry has been developed. A number of Risk Assessments were undertaken by Railned in 1994–1996 as an essential part of the drafting of the safety strategy by central government and by Railned itself. The availability of a proper database is indispensable for this. The setting up of a complete information system has been taken in hand with vigour. The supply of standardised data by all those involved in the rail transport system is a requirement for this. Due to the privatisation of NS [illegible] and the advent of new entrants to the Dutch railway network, new agreements have been made on annual plans to be produced and on safety reporting.

Comparison with other railways and other sectors is necessary to be able to judge the position of safety in our own situation. A proper definition of the safety aspects is important in this, as well as the exchange of data.

Risk assessment is a good tool to chart safety activities and to appeal to participants in the rail transport system to create improvements and is of major importance in risk analysis.

The assessments undertaken indicate that the priorities in short-term safety work lie in the [illegible] and [illegible], on level-crossing safety and on the safety of trespassers, [illegible] in particular.

An important point for attention is the development of tools to determine the changes in group risks as a result of new activities.

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Paper 9629

Francis Callard

Implementing Rail Safety as a process in a Railway in Transition

CURRICULUM VITAE

Francis Callard

Francis Callard is Senior Manager, Information Systems, at Spoornet where he is involved in Spoornet's IT enabled transition to a customer focused, process based organisation. He is active in bringing together the disparate views of business, technology and safety into a unified process and is current chairman of the Safe Rail Management Systems Committee, which developed the Principles for Safe Movement on Rail, and is now overseeing their implementation.

Previously he held positions in telecommunications and the maintenance, construction and design of railway signalling.
He holds a B.Sc. in electrical Engineering, is a Professional engineer and a member of the Institute of Railway Signal Engineers.

<u>INTERNATIONAL RAIL SAFETY CONFERENCE</u>

<u>CAPE TOWN : OCTOBER 1996</u>

IMPLEMENTING RAIL SAFETY AS A PROCESS IN A RAILWAY IN TRANSITION

SPOORNET - SOUTH AFRICA

[illegible]. Q. Callard
Senior Manager : Information Systems
Chairman : Safe Rail Management Systems Committee

Cape Town - 1996

INTRODUCTION

This paper is a short case study on defining the scope of safety within Spoornet and some experiences of implementing and maintaining safety while an organisation is undergoing a fundamental social and business transformation. After a brief background to Spoornet, the scope and depth of safety is outlined. This is followed by some of the factors driving change and by the response from the business and safety perspectives with the realisation that the responses are not synchronised. The subsequent actions taken to ensure and maintain synchronicity are briefly outlined.

BACKGROUND

Spoornet is the national railway carrier of South Africa. With a rail network of 21300 km, freight transport contributes 90% of its turnover. The South African Rail Commuter Corporation (SARCC) is the owner of the track and rolling stock in metropolitan areas, which is operated by Metro Rail, until recently a division of Spoornet. Trains from either party operate across the boundaries and into each others territories. This arrangement resulted from the commercialisation in 1990 of a common state enterprise with Spoornet having a commercial focus and the SARCC being subsidised to provide a commuter service.

With commercialisation, Spoornet changed from a common carrier to a commercial enterprise. Many of the organisations assumptions and the way of doing business were then no longer applicable to a commercial enterprise including the manner in which consignments were handled and the regulatory environment. Loaded wagons were routed to their destination using truck cards which dictated the shunting operations at the intermediate terminals. There was no explicit prioritisation of consignments and their transit and delivery times were erratic. Previously exempt from statutory regulations, Spoornet was its own judge and jury in respect of safety standards with Train Working Rules being developed over the years and training well established. The organisation had a satisfactory safety record but a noticeable deterioration was a spur to action as well as having to comply with new statutes.

IMPLEMENTING SAFETY PRINCIPLES

Last year I presented a paper on the development of Principles of Safe Movement on Rail. The following definition of safety was presented as reflecting the ethos that Spoornet wished to achieve.

> "Safety is the responsibility of every employee. It is the desired result of the interaction between components according to prescribed processes which ensures minimal risk of injury to life and damage to property and the environment. These components include:
>
> - the human factor
> - the design of the equipment
> - the designed process and
> - the process actually followed
> - the environment."

It is a prerequisite for safety that all staff are competent to carry out all aspects of their duties. The frame of reference against which the principles and their application would be measured was how well they promoted the concepts of :

- individual accountability and responsibility
- individual ownership of own safety
- individual ownership of organisational safety

It was not possible to just rewrite the Train Working Rules according to the Principles of Safe Movement on Rail as on examination the current rules contained many aspects which logically did not belong there. The following broad taxonomy was used to categorise the current rules into those relating to:

- Design
- Maintenance

- Normal Conditions
  - Operating System 1 ...
  - Operating System 2
- Partial failure and
- Catastrophic failure

The above categorisation follows a state-transition philosophy. Another view identified the following domains and categories within each domain:

<u>Domains of Safety</u>

Production	Support
Movement	General Administrative Rules
Interruption	Accident / Incident
Protection	Taking in / out of Service
Communication - Verbal	Maintenance
Communication - Visual	• Line - Infrastructure
Train Composition	• On Line - Rolling Stock
Inter Railway Working / Interface	• Control - Operating Systems
Social Impact	**Special Categories**
Public / Client Safety	Passenger Issues
Employee Safety	Hazardous Consignments
Sidings	• Identification
Level Crossings	• Packaging
	• Handling
	• Incident / Accident
	• Communications (Special)

The result of each category in turn would ultimately be a hierarchy of documentation comprising the following:

Policies	• Definition of principles • Excludes technology • Not time bound
Codes of Conduct	• A ruling document • To be used by all in the design/writing of manuals, instruction etc.
Codes of Procedures	• Technology inclusive • Works procedures – general • Long term time-frame
Working Instructions (Can include job and works orders)	• Technology specific application • Works procedures - specific • Short term time-frame • Absorb modifications • Research and development procedures
Local Instructions	• Technology specific - geographically bound • Apply works instructions locally • Absorb local differences

An integrated electronic medium has been developed with the ability to keep material up to date and relevant in a rapidly changing business environment. Spoornet's current Train Working Rules last underwent a major revision in the mid 1960's. Transforming the current Rules into ISO 9000 documentation based on the recently developed principles in line with the domains and document hierarchy is now a major initiative.

A PROCESS ORGANISATION

In 1995 Spoornet embarked on an information technology enabled initiative to transform its core-competency to a customer focused one of reliability and predictability. Cornerstone to this were the concepts of wagon reservations, works orders and run-down procedures. The process investigation contributed to the concepts that geographically focused regions were inappropriate to the new way of thinking, and that centralised working from a central hub would optimise operations. Some 80% of all consignments have the Gauteng area as their origin or destination. Measurements were instituted across 37 areas, enabling the Area Managers to benchmark themselves against their colleagues. This raised the visibility of individual actions and was in line with Spoornet's drive towards greater individual accountability and recognition of value added.

The internal organisation of Spoornet is also changing as the focus shifts from being a provider of infrastructure to a rail operator to a logistics player. Rail operations and marketing are in one department but the new direction of a two-stream Spoornet which separates the operations and marketing has already been announced and the appointments should be made shortly. The strong regional focus of the Spoornet is a historic legacy and has permeated the culture of the organisation. The corridor concept clashes head on with this culture and creates confusion at the operating level.

THE PEOPLE FACTOR

Also driving change was a consistent downsizing of the organisation and the loss of many skilled persons and the training they absorbed. There was and still is a need to fast track new recruits in line with competency based training whilst recognising that the maturity curve is a [illegible] one. When it came to the yard processes of compiling trains and pre-departure checks, the safety standards had been internalised by individuals to a high degree. The yard staff compiled trains first according to known criteria and secondly according to the consignments to be moved. Their operations planning is however being centralised to an ever greater degree with less freedom at yard level. This is to capitalise on expertise and guard against an inexperienced and inadvertently irresponsible action. The business driven processes for generating works orders and reservations were implemented in record time but they did not fully take into account the totality of existing rules and regulations around compiling trains. Time to implement and inexperience were the key contributing factors. The result was that yard personnel are sometimes issued computer driven works orders which are in conflict with their training. This creates a no-win situation. Complying with a works order may result in an unsafe situation but meet the performance criteria whilst not following the works order may be safe working at the expense of a dissatisfied customer and a poor performance measurement.

SAFETY

Before a train leaves a yard the train despatcher issues the driver documentation detailing the wagon consist and brake measurements certifying the safety/roadworthiness of each wagon and the train as whole. The planned wagon consist is computer generated according to the reservations but a current shortcoming is the lack of a closed loop process that will ensure that all faulty wagons are flagged before works orders are generated. This is to prevent work orders being generated which reserve place for a defective wagon on a train to an interim destination. Again, personnel should not have to make the judgement call of whether to meet their performance criteria or follow their training.

SYNCHRONISING BUSINESS, PROCESS AND TECHNOLOGY.

Recognising the shortcomings was the first step to rectifying them. The departments are sensitive to and aware of the need for continuous communication. Capturing the resulting knowledge however and being able to communicate it in the quickest and most cost effective manner was the challenge.

Spoornet is striving to create the empowered knowledge worker. This business literate person will be technology enabled to perform all aspects of his or her work and use technology to access help and assistance as the case may arise. Freedom of access is also there to encourage learning at every available opportunity. An example used is the process model on Spoornet's Intranet. This provides the conceptual and detailed processes of Spoornet using a recognised methodology. Each process is associated with its business drivers and the resources and processes required are identified. The total process is described covering electronic and human activities. Should the person be unsure of a particular activity, he activates the hypertext link and receives detailed instructions on the steps to be followed. The domain of these processes is currently primarily business focused, but will be expanded to include all knowledge that should be in the worker's toolkit.

CONCLUSION

In the time available, I have attempted to outline the scope of safety within Spoornet and the forces behind the current transformation, its scope and breadth as well as the difficulty in maintaining synchronicity between the elements of the organisation so that safety is not compromised. This is compounded by the different rate with which each element changes. Some success has been achieved in creating a framework to accommodate this rate of change as well as an integrated electronic medium providing staff with on-line help in the facets of the business, commercial and safe working. Completing this work is the next challenge.

I am grateful to my colleagues and Spoornet for the input they have provided into this paper and the opportunity to present it.

1996 CAPE TOWN

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The Lord Charles Hotel, Cape Town, South Africa

Paper 9630

Don Davis

Tranz Rail Ltd's Safety Management System Experiences with the Legal Process

Publisher
[illegible] International Rail Safety Conference

CURRICULUM VITAE

Don Davis

Don Davis is from Tranz Rail Ltd, New Zealand, where he has the position of Corporate Manager of Quality and Safety.

He commenced working in the transport environment as a graduate professional engineer. He has held many positions in the Company during his career, but in the last seven years has been a team member of the recently formed Corporate Quality and Safety Unit. He is now team leader of the unit.

The purpose of the unit is to provide strategic direction and overview Tranz Rail's systems and risk management programmes.

Key issues that Don is currently directly involved in:

- Company's liaison with rail regulatory authorities.
- Legal issues resulting from occurrences.
- Investigation into the most serious rail occurrences.
- Mainline derailments
- Track Warrant Control review
- Crisis Management planning for the Company
- Audit programme.

INTERNATIONAL RAILWAY SAFETY

SEMINAR 1996

Tranz Rail Ltd's Safety Management System Experiences With the Legal Process

D S Davis
Corporate Manager
Tranz Rail Ltd

1.0 INTRODUCTION

Following a tragic accident when a young lad fell from a passenger train in July 1994, Tranz Rail Ltd was charged under the Crimes Act 1961 for Criminal Nuisance. The case went to the High Court and was heard in February 1995. The trial of the charge involved close scrutiny of our Safety Management Systems. The charge was dismissed following presentation of part of our evidence. This paper draws some key lessons to be learnt which I share with you today.

2.0 BACKGROUND

To understand the issues one needs to briefly describe the legal framework. In respect of train accidents there are two avenues for potential prosecution in New Zealand:

- The Health and Safety in Employment Act 1992.
- The Crimes Act 1961.

The Health and Safety in Employment Act, broadly speaking requires that "all practicable steps" are taken to ensure safety. This Act is a penal statute. The offence provisions by way of fines are often described as regulatory offences and are seen as far less serious than any Crimes Act offence.

Tranz Rail Ltd was not prosecuted under the Health and Safety in Employment Act. The reasons behind the Labour Department's decision not to prosecute is not known.

The accident received a high public profile. The police investigated the accident, and eventually concluded after it had been reviewed by the Police Legal Division that they should proceed with a prosecution for Criminal Nuisance.

Allow me to explain the elements of Criminal Nuisance and what the relevance of a safety system was in terms of disproving or casting doubt on the prosecution's case.

Criminal Nuisance is committed by anyone who -

> *... does any unlawful act or omits to discharge any legal duty, such act or omission being one which he knew would endanger the lives, safety, or health of the public, or the life, safety or health of any individual. (Crimes Act 1961, s145).*

It is also necessary to explain that the legal duty under section 156 of the Crimes Act is the duty to take care when operating dangerous things:

> *Everyone who has in his charge or under his control anything whatever, whether animate or inanimate or who erects, makes, operates, or maintains anything whatever, which, in the absence of precaution or care may endanger human life is under a legal duty to take reasonable precautions against and to use reasonable care to avoid such danger, and is criminally responsible for the consequences of omitting without lawful excuse to discharge that duty.*

The safety system was put forward by way of defence to demonstrate that Tranz Rail had in fact taken all "reasonable precautions" and did "use reasonable care" to avoid such accidents.

The effect of the criminal prosecution process on the company and its staff was significant and absorbed considerable time and costs. The outcome of the trial could have had considerable consequences for Tranz Rail Ltd's business, its staff and the wider business community generally.

3.0 RELEVANCE OF SAFETY SYSTEMS IN LEGAL PROCEEDINGS

- It is not realistic to think in a case like this that the Company would have been completely blame free in the widest sense of the word "blame". After all, the accident did occur and if civil liability for compensatory damages existed, the company could well have been liable. In New Zealand law, personal injury claims are managed by way of a statutory regime which precludes civil litigation for compensatory damages in return for statutory compensation.
- The place which a safety system will have in a set of legal proceedings will depend entirely upon the nature of the proceedings.
- No matter how good a safety system is, it will not be a defence against the criminal act of an employee though which, through deemed or express vicarious liability under a statute, the company is exposed.

- Traditionally the criminal law only imposes liability for the commission of an offence on the person who has committed the offence. If it is an employee then the employee, not the employer, is guilty.
- The only way that a company could be liable for an offence under the Crimes Act (or equivalent penal code in other countries) is for the company itself to have failed. In a case involving criminal nuisance, to find failure to take care (or negligence as it is better called) by the company it is necessary to look at what steps the company itself should have taken to avoid such an accident as opposed to the carelessness or omission of a subordinate employee.
- Looking at the actions of the company itself the adequacies or inadequacies of a safety system come clearly into view because the contents of the safety system and its implementation and monitoring represent the company's own acts.
- In a significant railway mishap there is the likely concept of a statutory commission or Board of Inquiry would put the safety system under close scrutiny and likely to be in a broad-ranging way.
- A note of caution. There is an increasing number of statutes which impose vicarious liability for offences, i.e. employer or the employee is liable for the criminal act (for example, the Health and Safety in Employment Act (NZ) or the Health and Safety at Work Act (UK)). Safety management systems may not be seen as a defence in these cases.

4.0 SAFETY SYSTEM REVIEW

4.1 At the time of the accident (2 July 1994) Tranz Rail Ltd's Rail Service Operating Licence, a key element being the safety system, had been effectively deemed to be approved based on historical operation and performance. However a law change in 1992 meant that by April 1996 all rail operators had to have an approved "modern" safety management system which met the specific requirements of the law, to continue to maintain this licence.

Tranz Rail Ltd's modern safety system was approved in December 1995 and was integrated with the company's ISO 9000 series certification.

Tranz Rail Ltd's safety management system is an advanced documented system well in the forefront of international railway applications. However allow me to share with the conference the need to continually maintain and review systems especially those rail operators that are working in a business environment of rapid change.

Senior management needs to be vigilant that the spirit and the letter of the safety management system is being carried out in practice throughout the organisation at all levels. To do this there needs to be commitment of time and resources by the line function, particularly in operations and engineering as well as at corporate level.

4.2 SAFETY POLICY

- The company policy was documented and clearly spelt out from corporate management.
- It is essential that convincing evidence of effectiveness of the implementation and ongoing maintenance of its policies can be brought forward in the legal courts.
- There is a need to regularly measure the actual day to day perception of the managers and staff to ensure corporate office policies are being met.

4.3 SAFETY MONITORING

- At the time of the accident, Tranz Rail Ltd had in place an accident/incident system to record all safety events.
- Consultation with a wide internal audience was achieved in its preparation and implementation.
- Informal and formal feedback systems to corporate level are needed to be confident that accidents and incidents are being reported. All levels of management are encouraged to spend time out in the field and maintain people contacts. This is commonly referred to as "management by walk-about", and these events are diaried for purposes of recall if necessary at a later date.
- It is vital to encourage ownership of quality and safety functions at all levels in the company and to encourage reporting of all non-compliance's and observations, as well as accidents and incidents.

- The need for feedback to staff by way of trend analysis and specific event causes are essential in maintaining the reporting system and requirements of the Health and Safety in Employment Act.
- We have now consolidated monitoring to encompass all quality, safety and environmental occurrences (including non compliance's) by using one system for all risks to the business. This system is known as our occurrence management system and is subject to the quality audit process.

4.4 SAFETY AUDIT

- The audit system in place combines quality, safety and the environment and was judged to be fit for the purpose.
- The audit programme covering a three yearly cycle for the whole business is currently being reviewed. Tranz Rail Ltd is aware of other systems that work on a annual audit basis for specific components of their business system.
- Tranz Rail Ltd's audit programme is executed by suitably qualified internal auditors. Audit outputs are reviewed by external auditors. The external auditors have been approved by the transport regulator. The audit system is now I.S.O. certified.
- At the time of this accident the company was moving to cover safety auditing within the quality auditing regime.

4.5 ORGANISATION REVIEW

- Tranz Rail Ltd had a system in place modelled on UK practice to validate organisational changes. Retrievable evidence that the process has been used in accordance with policy is essential.
- Maintenance position descriptions including boundaries for responsibility in relation to codes etc need to be demonstrable.
- The clearest evidence of an inadequately implemented or monitored safety system is one which, while it makes provision for a certain step or process nevertheless fails to ensure that that step or process is being fulfilled or carried out.
- The "change process" review needs to ensure all business risks have been adequately addressed (i.e. authorities, responsibilities and resources)
- The lesson to be learned from this is that when the restructuring or other corporate change involves the disestablishment of positions then the duties which a code or procedure requires to be fulfilled must be given to others and there must be some clear evidence of an analysis having been carried out to ensure that those to whom duties or responsibilities have been passed have the capacity, knowledge and experience to fulfil those duties and are doing so.
- Alternatively, if the performance of a duty in a safety system as a result of some corporate change is to be dispensed with then there needs to be evidence that an analysis has been carried out to ensure that the discontinuance of the procedure is supportable.

- A key concern is to be able to demonstrate that the people in the management have sufficient understanding and resources for their safety responsibility through appropriate training at all management levels.
- A key issue to recognise with the changing business function is the higher level of "new" railway career staff and this itself poses another challenge for all involved.

5.3 ENGINEERING SAFETY MANAGEMENT

The accident which was subject to a high court hearing occurred when a bracket holding a hand rail between two vehicles allowed the handrail to dislodge at one end and the result was that a young lad fell from a moving passenger train.

Technical evidence centred around four essential elements in the defence of the case:

- Company's internal instructions
- Competent staff
- Checks and inspections
- Technical and managerial oversight

5.1 CODES AND INSTRUCTIONS

- Tranz Rail Ltd codes rely on competent staff with experience and knowledge. Historically most maintenance staff competence and training have been received almost exclusively "in house". Such staff have acquired very considerable detailed knowledge of engineering practice and equipment. Use of this knowledge could be relied upon without always being explicitly set out in the Codes (G.S.R.E.P. Good Sound Railway Engineering Practice).
- Future employment patterns are likely to dilute this degree of "in house" training and experience.
- Therefore the Codes and Instructions may need to be revised to incorporate greater detail of task definition and content in a user-friendly manner. There is on going review over the content level or "balance" that needs to be incorporated in future Codes and Instructions.
- There is a need to ensure feedback systems are in place so that any problems identified at the work place can be addressed at the right level of management responsibility.
- Explicit measures outlawing unauthorised modification need to be introduced and strictly enforced.
- A process of controlled development or variations, managed as a project over a limited time, needs to be formalised to prevent unacceptable delays or loss of service availability occurring whilst the modifications are formally approved and released.

- Responsibility for such variations or concessions should be clearly identified in the organisational structure.
- All critical safety related components should have standards laid down, rather than leaving depots and workshops to set these for themselves.

5.2 STAFF TRAINING

- Tranz Rail Ltd staff currently undertake tasks according to their level of training and experience, sometimes gained only over many years of service.
- In future, it is anticipated that there will be greater use of maintenance staff who have received their training on basic skills external to the industry.
- This is likely to necessitate change to training and instructing such staff on entry to the industry.
- Therefore it is considered a need to certify those staff who are competent and are permitted to work on critical safety engineering equipment.
- Annual staff appraisals are seen as a key time to review and assess competency.

5.3 CHECKS/ INSPECTIONS

- Tranz Rail Ltd documented system of checks and inspection is clear and well documented.
- Staff responsible for the process have been identified and the frequency duration specified.

- The management system needs to ensure that there is a formal process laid down to facilitate the findings of such checks and inspections
- This process needs to be subject to subsequent audit

5.4 TECHNICAL OVERSIGHT

- It is essential that a competent technical function is in place for management of engineering assets.
- This includes responsibility for technical specification for practice, maintenance, repair, overhaul and modification of engineering assets, together with a continuing review and feedback of its operational performance and safety.
- The responsibilities need to be clearly defined in position descriptions in terms of scope ie. A systematic practice of recording and reviewing all safety related component failures or wear outs.
- Such data would be available to analyse to provide improved future in allocation of pending safety problems.

6.0 RECORDS MANAGEMENT

- For this case it was important to produce documented evidence to support the Company's position.
- Changing business needs, with consequent reallocation of responsibilities, means that demonstrable evidence of the process is a risk issue.
- With the advent of electronic mail (e-mail), many of the records, instructions etc were transmitted electronically between various staff

members. Retrieval of these in hard copy form is essential in the legal process.

- The use of e-mail for the feedback loop tends to remain personal rather than process driven and was not subject to appropriate security.

7.0 STRATEGIES TO MINIMISE EFFECTS ON THE COMPANY

This litigation case showed that the following strategies are important in minimising the overall effects on the Company throughout the proceedings: -

Staff communication

- Feedback to staff on Company's approach and status of proceedings.

Individual staff member support

- These 'at risk' staff need support both on and off the work site.

Media management

- Maintaining an information flow that gives an honest and balanced presentation

External communication ie

Customers – Maintain 'open' communication lines.

Political – Legal and moral obligations

Regulator - Compliance issues and still maintain a balance with other transport modes

Shareholders – Company actions and concerns.

8.0 CONCLUSION

- Overall, the Company safety performance was good and improving but this one event challenged the integrity of the whole monitoring system.
- Tranz Rail Ltd's Safety System not only survived scrutiny but from a number of points of view has survived with a margin of comfort.
- Whilst this event focused on a mechanical issue, the lessons to be learnt need to be addressed across all business operations.
- Media management is a key to ensuring the public understands the issues and gives public confidence that management was in control of the business throughout the process.

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7 October - 9 October 1996
The Lord Charles Hotel, Cape Town, South Africa

Paper 9631

Paul Godier

Learning from Safety Incidents

INTERNATIONAL RAILWAY SAFETY CONFERENCE

Cape Town

October 1996

Learning from safety incidents

Paul Godier
Head of Safety and
Environmental Development

LONDON TRANSPORT

International Railway Safety Conference

Cape Town, South Africa

October 199[illegible]

Paper by Paul Godier, Head of Safety and Environmental Development
London Transport

"LEARNING FROM SAFETY INCIDENTS"

1. Executive Summary

1.1. Whilst the ultimate objective of a railway administration is to provide a service without incidents happening at all, even the best run systems suffer [illegible] events from time to time, many of which lead to human injury, loss of output, or physical damage to assets.

1.2 These incidents, if reported and properly investigated, offer an opportunity to learn from experience and to introduce improvements that can prevent similar incidents from reoccurring.

1.3. London Underground Limited (LUL) has recently undertaken a review of the approach to incident investigation in a number of other organisations, both within the railway industry and in other high risk industries. The aim has been to identify best practice in learning from incidents and to adapt this to the Underground, thereby improving the effectiveness of our investigation efforts.

1.4 This paper summarises the approaches used by these organisations, and the lessons which we in London Underground draw from their experience.

2. Introduction

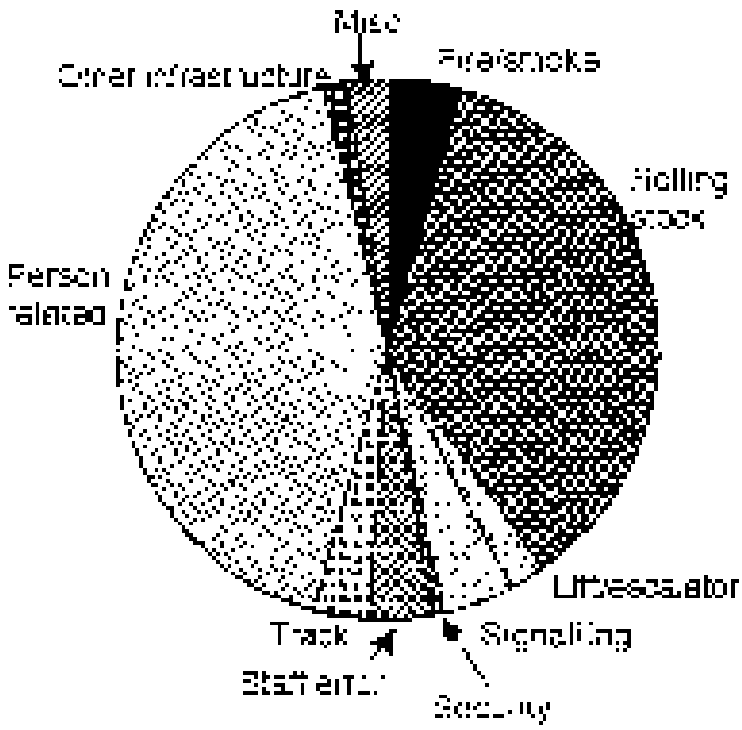
2.1. London Underground introduced a comprehensive incident reporting system in 199[illegible], to cover all losses (human loss, such as accidental injury or death; loss of process, such as train delays and station closures; and physical loss, such as damage to property). The reporting system also requires near misses to be reported. An incident is therefore defined as an undesired event that results in, or under slightly different circumstances could have resulted in, harm to people, damage to property or the environment, or loss to process or service. A single incident reporting form is used, which incorporates mandatory information and optional sections according to the nature of the incident (See Annex A). The form also includes a quality scoring system to enable managers to give feedback to reporting staff on how well they are using the form. All incident details are entered into a computerised database centrally.

2.2. The reporting of incidents is followed by a graded response to their investigation. Simple low consequence incidents are generally investigated and acted upon locally. More serious or potentially serious incidents are the subject of a formal investigation and report, with identification of immediate and basic causes, and recommendations to avoid a reoccurrence. Some of these formal investigations are subject to a Senior Manager Review, which is intended to ensure that the formal incident investigation has correctly determined the causes and that recommendations made are appropriate and complete. The process is governed by a Loss Control Standard [illegible] within the

LUL Safety Management System. The standard makes consistent and comprehensive incident reporting and investigation a mandatory company requirement. The categories of incident to be subject to investigation at each of the levels described above is detailed and prescriptive.

2.3. In 1995, 51,000 incidents were reported. Of these, 4,100 involved personal injury, and 16,000 caused loss of process – [illegible] delays to the service of 2 minutes or more caused by factors such as signal failures, track and rolling stock defects, staff absence, etc. The breakdown was:

INCIDENT TYPES 1995



Formal incident investigations were conducted for 257 incidents, and of these 6 were subjected to a senior manager review.

2.4 London Underground has recently begun a programme to review the way it captures and records incident data and the process of incident investigation. There is a feeling that the investment of effort is not always commensurate with the benefits gained. The quality of investigation reports is very variable. Too many repeat incidents are occurring, which suggests that the real root causes of incidents are either not being identified, or not being fixed. The large number of recommendations made each year are not always well focused; not always tracked or implemented; and relevant recommendations are not shared widely enough throughout the business.

2.5 As part of the process of determining a better approach for the future, the company sponsored a review of incident investigation in some other United Kingdom (UK) railways, and a sample of other high risk industries (nuclear, air, offshore etc). (Ref. 2) This paper reviews the experience of these other firms, and describes the changes which LUL proposes to pursue.

3. The UK railway experience

3.1. The incident investigation regime on the national rail network formerly owned by British Rail (BR) is still a common system, despite the process of privatisation now underway. The approach is largely as inherited from BR, and laid down in a Group Standard, of which Railtrack (the company which owns and operates the track and signalling system) is now the custodian, and which applies to all companies operating over, or associated with, Railtrack's infrastructure, known as the Railway Group (ref. 3). This specifies the types of incident that should have a formal inquiry and the basic approach to be adopted, including the level of a panel, its team composition, and the format of the report. Emphasis is placed on identifying root causes and practical actions to prevent recurrence.

3.2. One development since Railtrack was formed is the use of a panel of independent incident investigation leaders, largely composed of retired BR staff. This has been necessary to provide some reassurance to the parties to the incident that the investigation will be impartial. (The original arrangement, whereby Railtrack led most investigations, had the disadvantage that Railtrack had a vested interest in the outcome, because the result of the investigation could have commercial or other implications.) It is possible that in due course an independent railway incident investigation commission may emerge in response to this tension. Indeed, a number of countries now have cross modal investigation bodies (see ref. 4). In the meantime a further development which might aid the emergence of the full facts is the use of the minority report, by any party to the investigation who feels the majority report has failed to identify the causes or solutions correctly.

3.3. Other issues encountered in the operation of the present system of investigations include:

3.3.1. "Blame". As well as the problem of the attribution of contractual fault mentioned above, there is also the difficulty of individual blame in an investigation. Getting to the truth can be hampered if those involved fear personal blame. Whilst BR, [illegible] and Railtrack seek to foster a blame free culture as regards safety incidents, this is difficult in practice, especially when staff know that, for example, drivers who pass a signal at danger more than three times are usually removed from driving positions.

3.3.2. **Root causes and human factors.** It has been recognised for some years in the UK railway industry that incident investigators have paid insufficient attention to human factors in determining causes and solutions. BR have worked with human factors specialist Prof. James Reason to develop the Railway Accident Investigation Technique (RAIT) which focuses attention on the types of human factor that often lie at the heart of accidents. In particular, attention is directed to latent conditions, or underlying organisational factors. Prof. Reason has previously analysed a number of major disasters, including Three Mile Island, Bhopal, Challenger, Chernobyl, Herald of Free Enterprise and Kings Cross Underground station (ref. 5). The striking thing about the identified root causes is that the vast majority are associated with management, design, systems and organisation. This contrasts with the tendency of many traditional incident investigations to attribute causation to errors (slips and mistakes) by those immediately involved in the incident. Training in incident investigation increasingly seeks to equip managers to dig deeper than these immediate causes.

3.3.3. "Black boxes". Since the Hidden report on the Clapham rail disaster (ref. 6), there has been a considerable increase in the number of trains fitted with [illegible] accident data recorders ("black boxes") along similar lines to those fitted to aircraft. The Group Standard is under review, with the aim of specifying the minimum information to be captured by the drivers

3.3.4. **Confidentiality during the investigation.** It is important that confidentiality of evidence is reserved during the course of an investigation, since selective leaking of evidence can cause premature and unbalanced views of the causes to emerge, and influence the evidence given by others subsequently. This requires that those giving evidence, and the investigators, are very clear in advance that confidentiality during the investigation is required, and firm handling of any breaches.

3.3.5 **Recommendation follow up.** Greater attention is needed in future inquiry reports to categorising recommendations as to whether they are of local or national importance. This helps to ensure that on the one hand all the parties who can learn from a finding are aware of it, and on the other hand that players in the industry are not swamped by irrelevant findings.

4. Off shore oil

4.1. The offshore exploration and production industry is, like UK railways, governed by a safety case regime. Since the Piper Alpha disaster, incident reporting and investigation has become more risk focused in the company that participated in this review. As with the UK Railway Group, there is a similar documented procedure for incident reporting and investigation. This oil company uses the Du Pont STOP (Safety Training and Observation Programme) technique to help detect and correct unsafe acts, and to supplement reactive incident reporting with proactive and blame free observation of safe conditions.

4.2. Issues that the oil company raised from their experience included:

4.2.1 **Inexperience.** As with many organisations, incident investigation is the responsibility of local managers and supervisors, who are individually inexperienced in the art of investigation, because of the relative infrequency of incidents serious enough to warrant an inquiry. Guidelines and checklists are issued to help overcome the problem, but this is not wholly successful.

4.2.2. **Business focus.** The company concerned had a bonus system based on lost time accidents, which was diverting attention from the more important safety issue of hydrocarbon releases (eg gas leaks), which got insufficient management attention.

4.2.3. **Root cause analysis.** The company used the MORT (Management Oversight and Risk Tree) technique to structure analysis of underlying causes. This fault tree approach is theoretically sound, but was felt to be academic and difficult to apply in practice by investigators.

4.2.4 **Work pressures.** Finding the time to conduct thorough investigations, and release of personnel to aid fact finding, was difficult given the other pressures facing staff and managers.

4.2.5. **Length of time.** Partly because of the above, and partly for other reasons, it was often the case that investigations took a long time to report their findings and recommendations.

5. Air

5.1. The regime governing the investigation of air incidents/accidents is very different to that which exists in the UK railway industry. Firstly, it has an international basis, being [illegible] by these devices.

3.3.4. **Confidentiality during the investigation.** It is important that confidentiality of evidence is preserved during the course of an investigation, since early leaking of evidence can create premature and unbalanced views of the causes to emerge, and influence the evidence given by others subsequently. This requires that those giving evidence, and the investigators, are very clear in advance that confidentiality during the investigation is required and the handling of any breaches.

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6.2 Issues identified by the participating nuclear operator include:

6.2.1. Root causes. This has also proved a difficulty for this company. The event reports require managers to select a root cause classification, and reporting managers typically select superficial categories such as staff error, or equipment failure. In formal investigations, these are led by line managers. In the past these have been led by managers without adequate levels of experience or training, and the quality of investigation has suffered. A new approach has been introduced, whereby investigations are led only by line managers who have been specially trained in investigation techniques. Every business unit of the company has one or two managers qualified to lead investigations. They are taught a range of techniques including a variant of MORT. They lead investigations in incidents on their site (so "ownership" and local knowledge are retained).

6.2.2 Business focus. There was a feeling that the emphasis within the company was somewhat unbalanced, with too much attention given to the effect of incidents on commercial reputation rather than occupational safety. Within occupational safety, the emphasis on radiological exposure was at the expense of traditional occupational issues such as trips, slips and falls.

6.2.3. Follow up. There is a company wide data base of recommendations and their follow up. Actions are audited. Failure to close out recommendations is reviewed at Director level.

7. Conclusions

7.1 There is no magic formula for incident investigation. In part the choice of approach will be governed by factors such as:

- the safety culture and maturity of the organisation
- whether the organisation is commercial or non-commercial
- the regulatory and legal framework
- the scale of risks and incident levels faced.

7.2. London Underground seeks to continuously improve its safety management regime in an evolutionary way. It has reviewed the lessons from the other companies, and decided to tackle the following issues:

- selection of incidents for investigation
- investigator competence, training and resources
- report quality and experience sharing and feedback
- the number and relevance of recommendations, and implementation tracking
- blame orientation.

7.3 The proposed changes to the LUL approach are set out under these headings.

7.3.1 Selection of Incidents. It is proposed that in future the criteria for deciding which incidents to investigate should be more selective. (The existing criteria are prescriptive and poorly adhered to). The criteria would take account of:

- the risk potential of an incident
  whether the incident is part of a notable trend
- whether the incident appears to offer particular learning potential
  whether the incident gives rise to grave public concern

Managers would be given considerable freedom as to which incidents to investigate within the criteria. The decision not to investigate should be recorded, with the reasons. The aim is to secure quality rather than quantity.

7.5.2. **Investigator competence, training & resources.** With fewer incidents investigated, it is considered feasible to ensure that they be led only by those trained in investigation (although investigation teams should always include representatives of those directly involved with management of the operations affected by the incident). Investigation leaders should be selected on the basis of competence (operational experience, analytical ability, inter-personal skills, etc). They would be part time, carrying out a line management role between investigations to maintain credibility and understanding. They would be available to investigate incidents in business units other than their own if a degree of independence was seen to be required. Their training would concentrate on the understanding of a range of tools and techniques relating to running investigations, interviewing strategies, root cause analysis etc. At present LUL is attending investigation courses run by others (BR, nuclear, and the Transportation Safety Board of Canada) to learn from them. It is recognised that management and organisational errors are the most difficult to get accepted, and the easiest to refute.

7.5.3. **Report quality and experience sharing.** Reports are to be shared more widely, which will help improve learning throughout the organisation (rather than just in the business unit where the incident occurred) and may also help improve the quality of reports, if it is known they are to be reviewed widely. Investigators should be required to indicate which [illegible] they believe to be of general relevance. The reactions of other business units to the relevant recommendations should be fed back.

7.5.4. **The number and relevance of recommendations, and their tracking.** The use of trained investigation leaders should help ensure reports and recommendations are more focused on the true root causes and their cure. Investigators are not always best equipped to determine the best solution to a root cause. Where appropriate they will be encouraged to identify the issue, and leave the responsible management team to identify reasonably practicable solutions to the issues. With fewer investigation reports, the comprehensive tracking of the implementation of recommendations and their close out should be simplified. A company activity monitoring database is to be enlarged to include the implementation of investigation recommendations.

7.5.5. **Individual blame culture.** Investigators will be trained to focus on the root causes of incidents, rather than stopping once "blame" can be attributed. Any disciplinary action will be left to the managers concerned, based on the facts identified by the investigation, and any other factors they see relevant.

7.5.6. At present, this new approach is being piloted on one line. Competence based selection of the first investigation leaders, and their training, is underway. This will be followed by a review and roll-out until the quality of investigations is improved.

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LUL Incident Notification Form

Form Completion

Form Distribution

Scoring

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Paper 9632

Julian Lindfield

Developing a Living Safety Case

CURRICULUM VITAE

Julian Lindfield

MCIT, MIOSH

- Experience in running large front-line business units (trains and buses)
- Instrumental in developing the strategic plan for business privatisation
- Senior Consultant in safety and quality
  leading to
- Project Manager for the development of LUL's Safety Cases and support management systems
  leading to
- Now reporting to the LUL Board as Project Manager and Integrator of all key management initiatives (including Safety) into an integrated value for money corporate plan

Developing A Living Safety Case

by

Julian Lindfield

LUL Project Manager and Integrator

A Safety case is a document in which an organisation demonstrates its ability to conduct and maintain its operations in an acceptably safe manner.

Safety cases are used widely, particularly in industries such as nuclear power, offshore oil and chemical manufacturing, where operations are hazardous. In recent years, the production and maintenance of a safety case has become a feature of legislation where safe operation has to be demonstrated to a public regulator.

The use of safety cases was extended to railways under the Railways (Safety Case) Regulations 1994. Designed to ensure the continued safe operation of Britain's railways after privatisation, these regulations require all "railway operators" to prepare and have accepted Railway Safety Cases under arrangements supervised by Her Majesty's Railway Inspectorate (HMRI), which is part of the Health and Safety Executive (HSE). When accepted, the Railway Safety Case becomes the basis on which the railway is permitted to operate. The Railway Safety Case, therefore, provides a framework for safe operation.

The Railways (Safety Case) Regulations 1994 came into force on 28 February 1994. Those operators operating on that date had two years in which to prepare their safety cases. As an existing operator, London Underground Limited (LUL) had to develop a Railway Safety Case and have it accepted by HSE by 28 February 1996. Because LUL operates trains over track belonging to Railtrack plc (the company formerly responsible for what was British Rail infrastructure), a safety case also had to be submitted to, and accepted by, them for LUL train operations over their infrastructure.

London Underground has always interfaced with railway services provided by other operators. LUL and other rail operators' trains run over shared tracks, call at shared stations and provide pedestrian connections for passengers at adjacent stations. These interfaces and responsibilities for their safe management needs to be understood and monitored for compliance.

The privatisation of Britain's Railways will inevitably result in new operators entering the railway industry, each of which may present additions to interfaces and new divisions of responsibilities. This creates the potential for new risks which need to be understood and managed in order to ensure that safety is maintained at all times. To this end, the 1994 regulations require operators to prepare and maintain railway safety cases which address the process for identifying and dealing with such situations.

The regulations also introduce the principle that the "Railway Infrastructure Controller" (the business responsible for the track, signalling and the way the trains are "controlled"), has overall responsibility for safe railway operation over its infrastructure and submits its Infrastructure Controller Safety Case to HMRI. In the former BR situation, each company operating trains and/or stations then submits its safety case to the Infrastructure Controller on whose infrastructure their trains run or their stations serve. Where a station serves the trains of more than one Infrastructure Controller, special arrangements apply for the station operator to submit a safety case directly to HMRI.

London Underground is a publicly owned body, and, as such, continues to own and manage its infrastructure and stations. Consequently, the LUL Railway Safety Case covers all three aspects of its business:

- stations,
- trains, and
- infrastructure,

and must satisfy HMRI that the procedures, policies and systems are in place to run a safe railway and that these procedures are applied as a natural part of daily operations.

Possibly the most far-reaching safety specific project for many years, the Safety Case Development Project touched every part of London Underground's operations.

While the project team was driven by the legislative need to gain acceptance, it was equally focused on the moral imperative of identifying deficiencies in the way LUL managed safety.

From the start we were keen to ensure that good, open and honest relationships - internally with workplace, health and safety representatives and externally with BR successor companies, Railtrack plc and HMRI - were developed.

This meant divulging deficiencies and working with others to agree priorities and the way in which issues would be progressed.

It was only by facing up to issues in this way (rather than sweeping them under the carpet) that we were able to understand gaps, and recognise opportunities to improve the way we manage safety. By this means we prevented the exercise from becoming a paper driven justification exercise and turned it into a value-adding process.

The two year period for the preparation of Railway Safety Cases after 28 February 1994 only covered existing operations. So, when in April 1994, LUL acquired from British Rail the Waterloo and City Line, and the section of the Wimbledon branch of the District Line south of Putney Bridge, Asset Transfer Safety Cases were developed so that HMRI could grant conditional temporary exemption certificates under the regulations, awaiting acceptance of the full LUL Railway Safety Case.

With the newly acquired assets covered by an exemption, efforts turned to producing a safety case for the LUL organisation as a whole. After considerable research into how railway operators and other industries has structured their cases, it was decided to create a single safety case which was capable of meeting the requirements of the regulator. This was designed in such a way that parts of the document could readily be detached and adapted as train operator or station operator cases, thereby meeting the requirements of Railtrack plc. And other railway operators who would need to understand where and how interfaces would affect their operations.

The LUL project team established a set of guiding principles to be applied throughout the development process:

- LUL must work with HMRI, Railtrack plc and other operators in developing the case
- The Safety Case must not be a paper exercise, but must add value to the way in which safety is managed on a day-to-day basis.
- The Safety Case must not hide weakness
- The development process must be led from the very top of the organisation
- To ensure "ownership", the Safety Case should be prepared by the Line Managers who "owned" the risks and safety management processes necessary to address them. The use of consultants, for example, was confined to introducing industry best practice

Consultation took place with HMRI and Railtrack plc to ensure that issues and uncertainties arising during development could be resolved at the first available opportunity. It should be remembered that, in the early days, all parties concerned were undergoing a learning process and LUL, as an operator of considerable size, uncovered some unique issues which needed to be addressed. The working relationship established with HMRI and Railtrack plc was honest and open, enabling issues to be identified and dealt with.

Cross-functional teams from all disciplines and levels within the Underground organisation were brought together to identify ways in which safety was managed and, indeed how systems and processes could be improved. A two-year process of review and improvement - led from the top and touching every part of the organisation - followed. To help resolve specialist issues, a series of Functional Groups for trains, stations, infrastructure, policy and standards was set up.
The heads of these groups worked directly with HMRI and Railtrack plc to arrive at mutually acceptable ways of explaining and describing processes, policies, standards and procedures. The Standard Functional Group, dealing with the reconciliation of London Underground's standards and procedures with the equivalent Railway Group Standards, rightly expected by Railtrack plc in situations where LUL trains run over their lines, was particularly important.

By 25 January 1996, the London Underground Railway Safety Case was formally accepted by HMRI and Railtrack plc, enabling them as Infrastructure Controller with an accepted railway Safety Case to accept formally the Train Operator Safety Cases of Chiltern Railways, South West Trains, Mainline Freight and any other company operating over our infrastructure.

The development process had delivered all that was expected – and more within the parameters mutually agreed with HMRI and Railtrack plc in the joint project programme. Moreover, the "guiding principles" established at the conception of the project were never compromised and are still intact.

The emphasis now moves to maintaining the Railway Safety Case, ensuring its on-going relevance, application and effectiveness in managing safety within our own business and on the part of third parties operating over LUL infrastructure.

"Acceptance by HMRI and Railtrack plc must not be seen as the beginning of the end but the end of the beginning. This has been the largest corporate safety review, covering all aspects of the way a business manages safety, that I have ever witnessed.

The lessons learned and the relationships developed must be used to best effect in the future if we are to realise our ambition in becoming a world leader in the identification of customer, employee and contractor risks and their management."

Brian Appleton
[illegible]

With this statement in mind, LUL's focus turned towards what had to be done in order to ensure that our safety case becomes responsive to change and self-sustaining rather than merely reflecting a "snapshot in time".

Moreover, our safety objectives for 1996 / 1997 centred on identifying and establishing process improvements and developing robust strategies and address key risks (area / function specific). This was seen to be a very progressive change of emphasis in contrast to the traditional approach of merely focusing on setting percentage increase / decrease targets for everyone to achieve, irrespective of the relevance to the various areas of our business.

Indeed, our number one safety objective became:

"... establish robust mechanisms for sustaining and improving the safety management processes described in the Safety Case and ensure implementation of the improvement actions within it."

Three cross-functional teams with representatives from across the company were established with the shared purpose to:

"Identify key business processes (to support and maintain a living Safety Case), establish current status and develop plans to rectify"

The teams were charged with looking at:

Team (1): Risk Assessment

- ensuring consistent application of workplace and customer risk assessment
- developing understanding of the linkages between customer / workplace and quantified risk assessment

- Facilitating the development of Line Safety Improvement Programmes based on identified risk
- Highlighting variations in risk assessment findings across our business units

Team (2) Gap Analysis

- Identify gaps against what is written in the Safety Case and how to resolve them
- Identify gaps in understanding
- Identify key weaknesses or process deficiencies
- Develop recovery plans (if/where necessary) including outputs from Teams 1 and 3

Team (3) Process Analysis / Management Systems

- Identify key processes to sustain Safety Case / Stay Legal
- Identify process deficiencies and rectify
- Engineer and install key maintenance processes across LUL

All three teams working with an objective of transferring their approach, learning and tool kit of management techniques, in order that our business units can apply the same approach to their future work, i.e. leaving Business Unit teams with a process to manage the key processes.

In addition, LUL was keen to ensure that everyone in the Company knew what the key processes were and, indeed, their own roles and responsibilities within the process.

In order to effectively capture all aspects of the Safety Case in the process, it was decided to base our work on the "RACI" analysis technique. RACI (Responsibility, Accountability, Consultation, Informed) takes the following approach:

- Identification of all activities from the Corporate and Line Volumes of the Safety Case.

- Assigning Responsibility, Accountability, Consultation and Information requirements to relevant Managers for every activity (this is achieved through a combination of interviews and facilitated workshops)

- Aligning the activities to corporate and local management system elements

- Examination of these management system elements for compliance and efficiency

- Identification and prioritisation of items for development and/or improvement

- Integration of these items into the Business Unit Safety Improvement Programme

This approach has assigned management roles and responsibilities at every level of the company, from Managing Director down through the organisation, taking away any opportunity to abdicate what are management responsibilities to our safety professionals. Moreover, this process has helped to identify cross function/Directorate dependencies and how interface issues should be best managed within the company and when dealing with other Railway companies operating over our infrastructure.

At a Corporate or Director level, the RACI approach creates a definitive framework for Safety Case compliance, support and implementation. Directorate interfaces are identified, communication paths defined and corporate documentation held up for examination in the same way as at Line Business Unit Level. Equally, the link between Corporate and Business Unit Safety Management is consolidated within one document that works from the top down in terms of the Railway Regulations and the role of the Infrastructure Controller, and bottom up through links to the Line Business Units.

Underpinning the RACI analysis is the ongoing process of Internal Audit (an independent audit carried out on behalf of the Infrastructure Controller) and Gap Analysis, as well as the results and recommendations of [illegible] safety audits. The [illegible] always aligned with the findings from the RACI analysis so that weaknesses are quickly identified and addressed and improvement opportunities seized.
The team have worked closely with their internal audit colleagues to ensure that Business Unit [illegible] and the exchange of information [illegible]. Information form Gap Analysis (to identify discrepancies between Safety Cases statements and operational practice) has also been incorporated to create the most comprehensive base data available.

With so many similar Business Units, the scope for economies, co-operation and the interchange of best practices or new ideas is clear. The team has taken on board the role of ensuring that the structure exists to make this happen. It has established a database of management documentation, both corporate and Line Business Unit, on which Safety Advisors can draw and refer to when programming improvement work and examining processes.

Our approach to developing the process/systems framework will leave the company with a legacy of best fit processes to sustain a living Safety Case, with no doubt at all as to "who needs to do what" to make sure it continues to live.

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Paper 9633

Lee Kai Wing

Development of a risk control process for Mass Transit Railway

CURRICULUM VITAE

Lee Kai Wing, George

Mr. Lee possesses a Bachelor of Science degree in chemistry and physics. His qualifications in safety include being a member of the Institution of Occupational Safety and Health, and a Fellow of the Permanent Way Institution. His work history includes [illegible] years experience in rail transport operations and safety management. He has worked on three railways, two of which are underground.

Mr. Lee is currently the Safety Services Manager of Mass Transit Railway Corporation, Hong Kong. He heads the Safety Services Department, which is responsible for assisting the Executive and line management in developing safety management systems, risk management and providing assurance on safety through an audit programme. Mr. Lee has hands on experience in the development of a risk based safety management system that meets the needs of MTRC.

Development of a Risk Control Process for Mass Transit Railway

George Lee
Mass Transit Railway Corporation

Synopsis The Hong Kong Mass Transit Railway has developed a risk control system that is pragmatic and emphasizes the importance of the management input. The system allows the Railway to prioritise its risk control expenditure and control its risk to a level that is as low as reasonably practicable.

1 Need for a Risk Control Process

According to [illegible][1] the role of risk management in industry and commerce is to:

- Consider the impact of certain risky events on the performance of the organisation;
- Devise alternative strategies for controlling these risks and/or their impact on the organisation; and
- Relate these alternative strategies to the general decision framework used by the organisation.

A risk control process for safety risks on the Operating Railway has been developed in Mass Transit Railway Corporation (MTRC), which will enable the Corporation to carry its risk management more effectively.

The purpose of the Mass Transit Railway Corporation (MTRC) is specified in the MTRC Ordinance, as follows:

"To construct and operate, on prudent commercial principles, a mass transit railway system having regard to the reasonable requirements of Hong Kong's public transport system."

Hence it is necessary to establish a reasonable upper limit of safety risk and to provide a risk based framework for cost-benefit analysis on control measures that reduce expenditure using a reference value for preventing a fatality, in order to systematically prioritise the return on safety investments.

2 Key Tasks of Risk Control Process

The Risk Control Process has seven key tasks (see Figure 1) as follows:

- Hazard Identification
- Hazard Registration
- Hazard Verification
- Remedial Action Proposal and Evaluation of Risk Acceptability
- Remedial Action Endorsement
- Remedial Action Implementation
- Hazard Update and Risk Profile Review

3 Hazard Identification

It is an accepted principle within MTRC that safety is line management's responsibility. Hence line management is heavily involved in the identification of hazards. In 1993, a multi-disciplinary working group comprising line management representatives conducted brainstorming sessions on the possible hazards of each equipment, system and recorded the results (probabilities and consequences) in spreadsheet format.

On an ongoing basis, the Manager responsible for each Section is required to identify hazards within its operation and to register the hazards in an interactive database called the Hazard Registration System (HRS). Other means of hazard identification include review of accidents and incidents, Job Safety Analysis, risk assessments as well as regular reviews.

In order to encourage lower level staff to report hazards, the Section Managers identified Hazard Coordinators to receive reports on hazards from their staff, using a standard form. A Section Manager will arrange for the hazards to be entered into the HRS after he is satisfied with the information provided.

4 Hazard Registration

The Hazard Registration System is an interactive database which provides a risk assessment matrix that automatically ranks each hazard entered into one of the four risk categories according to the frequency and severity of the adverse scenario entered. The risk categories are: R1 - unacceptable (demanding immediate action), R2 and R3 - hazards in the 'As Low as Reasonably Practicable' (ALARP) region, and R4 - Acceptable (no action required). When a hazard is entered, the Section Manager also proposes the manager of the responsible section as the Hazard Controller, i.e. the person responsible for controlling the hazards.

5 Hazard Verification

The HRS is maintained by a small group of risk control experts in the Risk Control Section. When a new hazard entry is received, Risk Control Section assess the credibility of the data entered and the appropriateness of the Hazard Controller assigned. This "verified" hazard is then submitted to a Risk Control & Analysis Committee (RCAC) for formal endorsement. The RCAC is chaired by the Risk Control Manager but has line managers as members. Its key role is to monitor and review the risk control performance of the railway, and to recommend risk control strategies.

6 Remedial Action Proposal and Evaluation of Risk Acceptability

An R1 item has to be addressed immediately to be reduced either through proposing control measures to reduce either the frequency or severity of the hazard, or by conducting a Quantitative Risk Assessment (QRA) to confirm the risk rating.

R2 and R3 risk items are required, as a matter of principle, to be reduced to R4, using the ALARP principle, in which the cost of the control measure is compared with the value of risks saved using a reference value of preventing a fatality. In the application of this methodology, the following aspects have to be considered:

- The reference value for preventing a fatality is only a tool to assist management judgement. In deciding the cost/benefit of a proposed measure, there should also be consideration of the actual risk level (e.g. upper R2 or lower R3), other benefits or drawbacks of the project, as well as other business considerations.
- It is generally accepted that a hazard item can remain at R3, whereas stringent scrutiny will be required in justifying a hazard remaining as R2. In addition, any hazard remaining as R2 must have its existing control measures classified as safety critical, for which more stringent control review systems are required to ensure its integrity.
- Any case where the cost of a remedial action exceeds HK$5 million, a QRA should be considered as a preliminary to the study.

7 Remedial Action Implementation

Hazard Controllers implement the control measures as stated above. The risk category is not reassigned until the control measure has been implemented.

8 Hazard Update and Risk Profile Review

Hazard Controllers are required to review the status of all hazards at least every six months and submit any changes to the RCAC.

The Risk Control Section will submit the risk profile (i.e. risk items broken down by risk category, equipment system, outstanding control measures, etc.) to RCAC for review and endorsement every six months. After the review by RCAC, the profile for R1 and R2 risks is submitted to the Safety Committee for review and endorsement. The Safety Committee is the forum for management and monitoring safety performance of the Operating Railway.

9 Conclusion

The salient features of the risk control process are that it is pragmatic and simple, and that it requires full participation of line management. The Risk Control Section are there to guide and provide expert advice, but not to take over line management's responsibility to monitor and control risks in their operations. The key to success is to involve line management throughout the design of the process, and to conduct effective communication and training workshops. In certain areas, trial implementation is carried out and feedback from line management used to refine the process.

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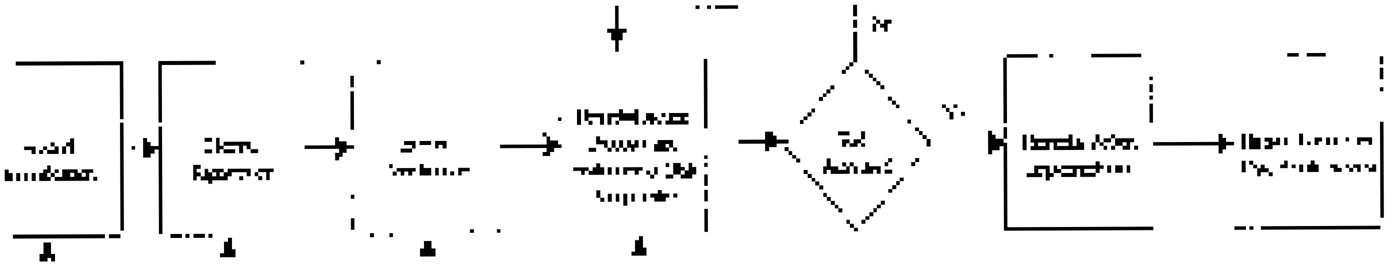
1 [illegible]



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Paper 9634

Terry Worrall

Privatisation or major structural change: Two prime risk areas

CURRICULUM VITAE

Terry Worrall

Terry Worrall is a career railwayman having spent 35 years with British Railways. The Major part of his career was spent in Line Management but in recent years he has worked at the British Railways Board Headquarters and since 1990 held the post of Director of Operations, Director Operational Standards and more latterly, Director Safety.

Since April 1994 his main task has been overseeing the transition from the original unitary organisation through the sale and franchising process to the current position, whereby British Railways now have 25 companies left of the original 100.

He has spoken on similar occasions at International Conferences. On completion of his task as Director Safety, once all companies have been sold or franchised, he will leave British Railways the end of March 1997 to join Halcrow Transmark as Director, Operations and Safety.

Privatisation or Major Structural Change - Two Prime Risk Areas

by

Terry Worrall
British Rail Safety Directorate

Two years ago, a paper entitled "Holding the Line - Leading People through Organisational Change", was introduced at the Hong Kong International Safety Conference.

At that time British Railways, together with Railtrack which had just been formed, were undergoing the biggest change since nationalisation in 1948.

Since that time many railways throughout the world have either undergone change or are about to undergo significant structural alteration, albeit not all are moving towards a privatised scenario - yet!

In the two and a half years since Railtrack was formed they have undergone their own changes - in particular, reducing the original 10 geographic Zones down to 7 - in two and a half years, therefore significant change to the people who were in the three Zones which have been closed down and amalgamated with other geographical areas.

BR, following the infrastructure split, was divided into 100 separate Companies of which 15 were Train Operating Companies, including the Engineering Maintenance and Renewal Companies engaged in Engineering Train Operation in April 1994. At that time BR had 125 000 employees - currently, it now has in the region of 45 000, and falling fast. BR now have less than 45 Companies remaining of which 15 are Passenger Train Operating Companies together with one Freight Operating Company and a number of other ancillary Companies yet to be sold/franchised.

Major change therefore - even greater change than any other major railway has experienced.

For this reason, two subject areas are identified which are worthy of attention and consideration as moves are made along the path of change both with organisations and safety management structures.

With any organisational change there is always a risk - the risk is that the Managers will have their attention elsewhere and that safety performance will deteriorate. After the Clapham Accident in the UK in 1988, a Public Enquiry was held during which it became clear that the effects of some aspects of organisational change had not been taken into account by management, resulting in deficiencies which contributed to the course of the Clapham Incident.

Immediately thereafter, in response to one of the recommendations by Anthony Hidden, the BR Board introduced an organisational validation procedure - this procedure has been outlined in papers at earlier conferences. As a consequence of this procedure, a greater discipline and more structure was brought into re-organisation proposals which were independently evaluated before introduction.
This validation structure was contributory to discussions leading to formulation of the UK Railway Safety Case Regulations which were introduced after the commencement of the privatisation process in April 1994. New structures, new disciplines and a need for assessment and "acceptance" by an "independent" body.

There are two significant safety achievements during this period of change and are extracted from the BR Annual Report 1995 / 1996, and shown as Appendix A.
Significant changes in organisation over a 5 year period have not adversely affected performance in key areas.

Papers by Railtrack and BR on earlier occasions have made reference to Railtrack having and Annual Railway Group Safety Plan and hitherto the BR Board have had a complementary Annual Safety Plan with its own objectives which are complementary to those in the Railtrack Group Plan. Last year, Objective 2 in the Group Plan related to Objective [illegible] in the BR Plan regarding rates per 50 million passenger journeys in respect of passenger fatalities. The BR Objective was that there should be "no worse than one fatality in 50 million passenger journeys" - the figure in Appendix A indicates that this objective was achieved and bettered.

The BR Safety Plan for 1995/1996 had as Objective 2 a fatality rate involving employees of "no worse than 1 fatality per 10 000". The figure in Appendix A shows rates per 100 000 therefore when divided by 10 equates to .55 per 10 000 - therefore this objective was achieved.

However, there is no room for complacency in either of these indexes - other details can be provided about problems that were experienced with accidents and incidents during the year but it is not my intention to do so in this paper. Both Railtrack and BR have been complimented by the Safety Regulator, the Health and Safety Executives Railways Inspectorate, in recent Annual Reports about the generally improving safety trends. Some categories of accident and incident are, however, not showing a falling trend, however, and require more urgent attention.

The two areas for specific focus in this paper are Management of Safety Interfaces and Structural Disposition of Safety Responsibilities.

Management of Safety Interfaces

There is nothing new about safety interfaces – the most basic one in any railway operation is the interface between the wheel and the rail. There are other interfaces between railway employees and equipment e.g. drivers looking for signals and observing signals is a good example; drivers talking to signalmen and taking specific safety instructions in the case of signal failure, is another and one of the most basic and one of the most high risk interfaces between two individuals who by any definition must be regarded as carrying out safety critical activity.

Similarly, organisations have always liaised and worked closely with each other both internal organisations and external. The arrangements with external organisations have normally been the basis of established contractual agreements. Now that the railway industry is breaking up into individual parts, many of which are being privatised or franchised, there is an increasing number of contracts applying to all types of interface - many of these are in their infancy and have not yet been tested legally. Many accidents and incidents in the past have been caused by a breakdown of proper interface management and the need to ensure clarity in the contractual specifications as to responsibility is even more essential - in the past such a breakdown is unlikely to have been positively identified as a contributing factor.

In the U.K. the definition of "interface" has been identified as "a common point or boundary between organisations, people, systems, equipment and processes, where activities merge and responsibilities are exchanged". This definition can apply to other than safety interfaces, but for the purposes of this paper, reference is to safety interfaces.

The importance of identifying the safety interfaces which need to be managed positively is recognised by the frequent reference to "interfaces" in both legislation and other communications. The UK Railways Safety Case Regulations recognise that "a Railway Operators Safety Case must address the risks which are presented by the interfaces between the operation and activities of other railway operators and contractors".

Furthermore, they continue by stating that "for all Safety Cases, sufficient reports supporting factual information should be provided, including information about the undertaking, its equipment and systems, its location and interface with other railway undertakings, operations carried out and hazards present".

There are other references particularly with regard to interface with contractors mentioned elsewhere in the Regulations. From these brief extracts the importance placed upon this aspect by the legislators can be seen.

An example of the ways in which two Train Operating Companies, still in the ownership of the BR Board, identified their interfaces is shown in Appendices B and C – these further show that no template approach was used but the Companies were asked to devise their own methodology as the preparation of the Safety Case albeit with some guidance and consultation.

In 1995/1996 BR Safety Plan has as one of its Objectives, the need to "Control Risks which arise at the interfaces changed or created by the restructuring of BR". Further consolidation of Railway Industry Objectives through the Railtrack owned "Railway Group Safety Plan 1996/1997", provided for "interface management" to appear as Objective 1 – this read as follows:

"In the interest of safety at a time of restructuring, Railway Group Members will continue to review the management of interfaces presenting risks and, with interfacing organisations, jointly agree adequate controls".

The Group Plan is binding and mandatory in terms of its application upon all Railway Group Members, which include all Train Operating Companies in possession of Railway Safety Cases who work on Railtrack's infrastructure. BR's Safety Plan for the current year has, not surprisingly, as one of its objectives "To identify an control the risks associated with interfaces and to improve the management of shared risks and benefits".

The BR Safety Plan, which must be complementary to that of Railtrack, outlines the following action which all the "owned companies" need to observe:

Identify the extent to which their major risks are affected by new or changed interfaces and put in place appropriate controls.

Co-operate with, and contribute to, the process which Railtrack will be developing to improve the management of shared risks and benefits.

Identify key contractual risks and develop and maintain a robust system for assessing and controlling the risks associated with the selection and use of contractors.

Develop sustainable mechanisms for sharing safety performance data for common benefit.

Develop partnerships with suppliers and other Railway Operators where mutual safety benefits can be derived.

This is a clear demonstration of how both Railtrack and the Board wish to see interface management elevated to a position of greater priority as far as the Train Operating Companies are concerned.

Further evidence of the importance placed upon safety interfaces appears in one of the most recent publications from the UK Health and Safety Executive - the "Railways Safety Principles and Guidance (Part 1)", which replaces the old documents which many, even in foreign railways, recall being referred to as "the Blue Book".

This document contains 33 principles which must be addressed by those who seek to build new railways, new rolling stock or engage any new work or propose any significant modifications to existing rolling stock or infrastructure. It makes frequent references to interactions and interfaces.

As an example, Principle 1 relating to "safety mission" requires that the "design and construction of new and altered works, plant and equipment should, insofar as is reasonably practicable, ensure the safety of any other people who may be affected. Factors which need to be taken into account in the course of ensuring that this is the case must amongst other things address the "interaction between the Railway and its adjacent environment including physical interfaces…. ."

Principle 20 relating to "safe routing, running and control" requires that consideration be made for "the interface with communication and other systems", and Principle 22 relates to "safe operation of control" and requires that factors for consideration should include "the interfaces between the controls of the infrastructure, trains, stations and emergency services".

This is yet another important document from the Safety Regulation, outlining basic principles which requires consideration of interfaces as part of the integral safety management process.

Management of safety involving interfaces is critical to good safety performances – it starts with identifying the risks to the Company, identifying the interfaces, ranking them and then applying the necessary control measures commensurate with the level of tolerated risk. Positively identifying the need to engage this structured approach towards interface management is the first step. It was certainly not a step to be taken within the UK prior to the Clapham Accident – it was undertaken on an informal basis, this meaning that some of it was being done – but since that time it has been far more structured and is now a requirement in the legislation and other supporting documentation associated with Train Operation Activity.

More often than not, the identification of a hazard during the preparation of the Safety Case process will lead to identification of safety critical interfaces.

An example with which most delegates will relate, addresses the potential hazard of brakes failing on a train.

Using the simple 5 x 5 matrix which is a risk ranking Frequency/Consequence tool used by the majority of Train Operating Companies. For the purpose of this example it has been determined that there is a score of 5 i.e. frequency 1 (rare) multiplied by severity 5 for brake failure with control measures applied.

Without control measures that score rises from 5 to 15 with frequency being reassessed as 3 (not so rare) but severity remaining at 5.

From Appendix D the possible consequences of such a hazard together with the contributing factors can be seen. Furthermore the groups at risk are clearly shown. Whenever making such an assessment using the 5 x 5 matrix it is necessary to consider the Companies experience with the particular type of potential hazard identified. In the case of this example, "background" is given whereby it can be seen that the record so far is good – the brakes are normally "fail safe" and the brake system is certified in accordance with the requisite Railway Group Standard.

The control measures that this Company might seek to employ to ensure that the risk ranking is maintained at 5 rather than at 15 (15 would probably be unacceptable anyway) are shown in Appendix E.

In Appendix E, there are 5 essential control measures, each cross-referenced to the Company Safety Management System.

The conclusion in this example is that the risk would be low with the control measures in place. However, the safe train operation within the Company is dependent upon the integrity of the rolling stock – the performance of which is closely monitored. The Company have addressed this particular issue within their safety management system in a section devoted to Traction and Rolling stock matters, including the importance of safety related equipment.

However, what this example serves to prove is that without control measures the company is greatly at risk – in this case the specific hazard identified is that of "brake failure" – the interface here in normal circumstances will be with a maintenance organisation which may or may not be part of the Train Operating Company. Whilst one may acknowledge the contractual responsibilities of a maintenance contractor it must not be forgotten that the responsibility for ensuring that the traction and rolling stock is "fit for purpose" when in use on Railtrack's infrastructure is that of the Train Operating Company. It is therefore up to the Train Operating Company to demonstrate that processes are in place which adequately address the level of risk associated with the hazard concerned.

More recently a guidance document has been issued from BR Board Headquarters, compiled in conjunction with Railtrack Safety and Standards Directorate, as a means of helping Train Operating Companies with the "management of interfaces" - this guidance also gives an example of a systematic methodology and suggested tabular ranking of risks brought about by essential interfaces.

Safety Disposition

The second part of this paper relates to the process which within BR, has been entitled "The Safety Disposition Process" - this might also be called "closing the shop" as far as my Safety Directorate is concerned, as this will cease to exist at the end of March 1997, consequent upon the disposal, sale or franchise of almost all of BR's Companies. The smaller number, possibly 6, that may remain at the end of March 1997, will be managed in accordance with a contingency plan as far as safety is concerned.

Organisational validation has been mentioned earlier and an outline given as to how Railway Safety Case requirements provide the framework within which train operational activity can be managed safely. The organisational validation process provided a structural opportunity for companies to demonstrate that they had provided for all essential safety management responsibilities in any new or emerging organisation. The disposal, sale and franchise of individual internal companies within the BR Board was a different matter altogether - the question was asked whether or not disposal were merely the Board divesting itself of certain responsibilities. It was determined that the Board needed a process in order to ensure that it would not be left exposed in carrying out its remaining safety responsibilities by the disposal of a Company or a number of companies to the private sector.

The process has been designed to ensure that the Boards remaining responsibilities are not adversely effect by the disposal of a Company. It should not be seen in itself as giving either positive or negative assurances to a prospective purchaser about the value of a company. However, any safety responsibilities which following this process are identified as being disposed of by the Board could be declared to the potential buyer of that Company it is considered reasonable that the Board should declare them.

The process provides for the Company being disposed of to prepare a disposition statement which detail the following:

- *People*
  this section should identify whether all staff will transfer with the Company or if any will remain with the Board and the reasons for that - it should also address the issue of individual managers or other employees whose specific individual skill and experience are used by the Board for example in representing the Board on an essential working group

- *Other Physical Assets*
  this is not meant to include buildings as these are being dealt with separately but it does include such items as information management if there are issues of ownership and/or management of these systems

- *Health and Safety Responsibilities* discharged on the Boards behalf this should cover any responsibilities which the Company discharges on the Boards behalf - it should also include responsibilities relating to specific Inquiry recommendations.

The disposition statement will subsequently confirm that the assets and responsibilities have lapsed completely, or are to be

- transferred in total to the new owners
- retained partially or totally within BR

Each Companies disposition statement is submitted to a panel which is Chaired by a member of the Safety Directorate staff - this panel has an independent Assessor who will be the counter signatory of the eventual Disposition Certificate

The safety disposition panel will determine whether or not it is necessary to hear evidence form any members of the management team of the Company in question - i.e. the one being disposed of, sold etc.

As a result of this simple but important process a number of issues have been identified which if allowed to lapse unwittingly could have seriously embarrassed the Board

One issue concerned the Boards road vehicle operators license - whereby some Companies recently franchised, (because some of this disposition process was carried out retrospectively), were still operating under the

Boards operator license - they had not identified the need to get one of their own probably because in the "turmoil" they had not thought about it ! Secondly, several rail vehicles including a locomotive were identified as remaining in the ownership of the Board even though the Board was not aware of it - the Board being ignorant in this case could not have had a defence under law had any of these vehicles contributed to or been the cause of a mishap or accident on or about any of the railway infrastructures. Since this has been identified the vehicles have now been properly dealt with and the Board have no further liability in this respect.

It was only because lessons had been learned as BR progressed through the years with an improving safety management system - albeit within what is now a fragmented industry, that such a structured process was introduced - had we been engaging the same restructuring several years ago there is no doubt that thought would not have been given to this method of approach and serious issues involving liability for significant sums of money in later years would have been picked up.

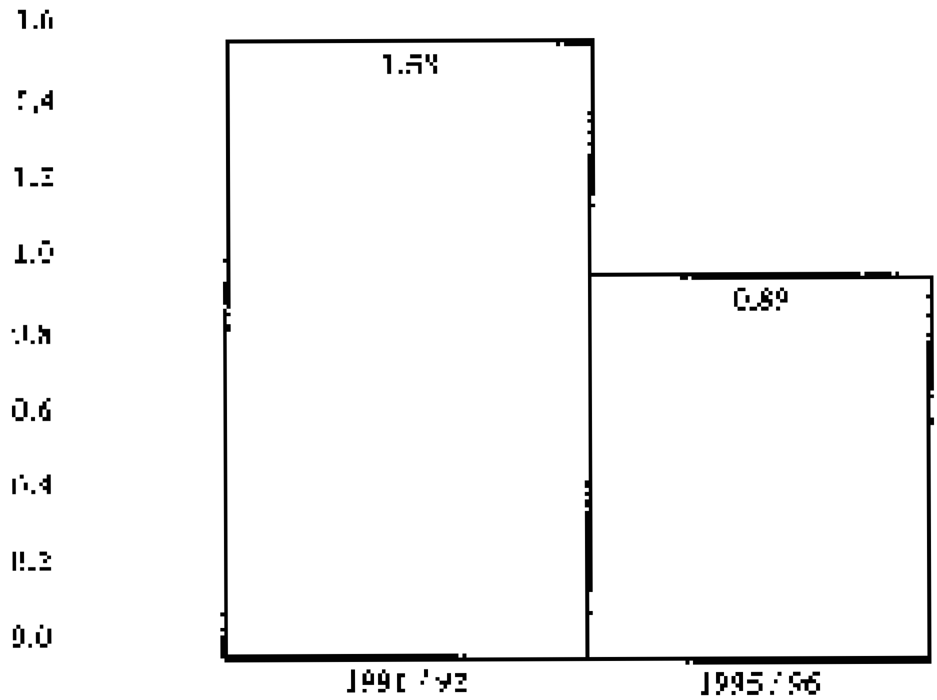
Whilst many of the organisations represented at the Conference will not be engaging the same level of restructuring or disposal, sale, franchising etc., it is appropriate to note the fact in the UK it has been found to be necessary to do this as there is no doubt that other railways will be disposing of some internal Companies or units from existing organisations. As railway organisations move towards focusing on core activities - even without the UK style full scale privatisation there will be a reduction in current internal ancillary units of organisations. Even where certain parts of the Train Operation are contracted out to Regional Authorities such a disposition process might well be appropriate particularly where contracting out goes to private companies rather than to other statutory public or nationalised bodies e.g. Regional Authorities.

The International Safety Conference objectives are all about sharing - sharing what is being done which could be a positive benefit to all and sharing what has been experienced since earlier conferences.
Continued sharing of this nature can only be beneficial to the International Railway Industry. The overall objective of every Company must be to satisfy or even delight the customer - this will only be done if train services are presented in an attractive and affordable manner with safety properly built in to all processes associated with train operations - in such a way that customers can take it for granted - as many of them currently do.

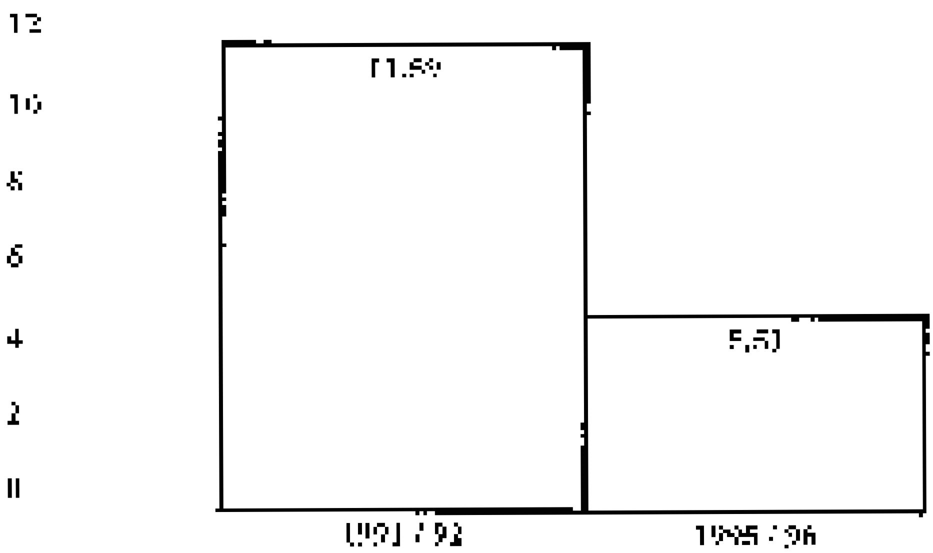
The two issues addressed in this paper have the potential to contribute to the overall safety "goals".

APPENDIX A

1. Passenger Fatalities
Rate per 50 million passenger journeys



2. Employee Fatalities
Rate per 100 000 employees
includes contractor employee fatalities



APPENDIX E

BOUNDARIES IMPACTING SAFETY BETWEEN CROSSCOUNTRY AND OTHER ORGANISATIONS, DETAILING MANAGERIAL RESPONSIBILITIES AND CONTROL PROCESSES

Areas of other organisations with which CrossCountry interfaces	CrossCountry staff most often involved in interface	Nature of interface	CrossCountry responsible manager	Method & periodicity of interface
Railtrack operational staff (signallers, Pilotmen)	Traincrew	Operational requirements under Rule Book and instructions, direct or by telephone	Commercial Manager, Production Manager and Customer Service Manager	Contract Specifications & local meeting (operations or safety)
Railtrack supervisory staff (Movements Inspectors, PSB Supervisors)	Traincrew	Operational requirements under Rule Book and instructions, direct or by telephone	Commercial Manager, Production Manager, and Customer Service Manager	Contract specifications & local meeting (operations or safety)
Railtrack Control	CrossCountry Control	Regular contact concerning safety & performance of trains and customers. Telephone/IT	Commercial Manager, Production Manager, Managing Director	Contract specifications, contract manager meetings, operational and safety meetings as required, daily liaison
Railtrack zone HQ staff	Safety & Standards team, Production Service Team, Commercial team	Train planning, incident liaison and follow up. Public Affairs requirements. Strategic Safety planning & review. Direct correspondence or telephone	Customer Service Manager, Production Manager, managing director	Operations & safety meetings, joint preparedness exercises at least annually, joint incident enquiries, contract review meetings at least annually
Railtrack Safety Auditors	Safety & Standards team	Audit process, Direct	Customer Service Manager	Audit meeting feedback
Railtrack Safety & Standards Directorate	Safety & Standards team	Railway Group Standard development & review. Operations, safety & technical groups. Major incident liaison. Railway Safety Case submission & amendments. Direct correspondence or telephone	Safety & Standards manager, Production Manager, Customer Service Manager	Safety Meetings including Standards Delegate Conferences quarterly and correspondence as required, review & input to consultation on proposed standards, procedures and changes [illegible] [illegible] currently [illegible] RSC

APPENDIX C

Interface Management

Key Interfaces

Railtest manages business organisational interfaces. Specific details of key interfaces are as follows.

INTERFACE	RAILTEST CONTEST	SUBJECT	FREQUENCY OF CONTACT
a) Assistant Civil Engineer Maintenance	Infrastructure testing (Special Trains Manager)	Weed Spraying Contract	Monthly Day-to-day
Ensures safe working of contract, discuss any problem and agree actions for the future			
b) Assistant Civil Engineer Maintenance	Infrastructure testing (Special Trains Manager)	Rail Grinding Contract	Monthly Day-to-day
Ensures safe working of contract, discuss any problem and agree actions for the future			
c) Assistant Civil Engineer Maintenance	Infrastructure Testing (Production Manager)	Infrastructure testing Contracts	Monthly Day-to-day
Ensures safe working of contract, discuss any problem and agree actions for the future			
d) National Freight Manager	Rail Operations Manager	Track Access Contract	Annually
Discuss track access requirements for Rail Operations and review implications with regard to planning and stabling			
e) S&SD Controller, Safety Assurance	QSE Manager	Railway Safety Case	6 monthly (Day-to-day)
To discuss the integrity and proposed changes to Railtest Railway Safety Case			

APPENDIX D

Example of a hazard description within a Railway Safety Case

HAZARD DESCRIPTION: Brake Failure

Risk Ranking	5	(frequency 1, severity 5)
Risk Ranking without controls	15	(frequency 3, severity 5)

Possible Consequences

Failure of this process could lead to train collision with other trains or buffer stops, or train over-speeding leading to a potential derailment.

Contributory Factors

- Failure to replace brake blocks during maintenance
- Isolation of excess numbers of vehicle brakes
- Freezing weather conditions

Groups at risk

Passengers on trains, train crew (especially drivers)

Background

There have been no instances of "wrong side" brake failures on the company's trains (1992 - 1995). Train brakes are designed so that failure will apply brakes. All T&RS used by the company have a certificate of conformance laid down in the set of Railway Group Standards GM/TM0001. This ensures the correct design of the braking system.

APPENDIX E

Control Measures
(Each reference to the company Safety Management System)

- All T&RS used by the company is subject to maintenance, with particular specific attention paid to the braking systems. All work carried out by competent staff and subject to audit
- Training of Drivers and Senior Conductors in Rules and Regulations appertaining to brake defects and the reporting procedures
- All trains are subject to train preparation before working each journey by Drivers.
- Brake and brake continuity tests are carried out on all T&RS as part of the maintenance schedule
- Post Incident Brake tests are carried out to comply with Railway Group Standard GM/TT0118.

Conclusion:

The risk is low with the present control measures in place. However, the safe operation of T&RS is dependant upon the integrity of our rolling stock, the performance of which is closely monitored. A specific section within our Safety Management System is directed at T&RS matters and particularly safety related equipment thereon.

1996 CAPE TOWN

[illegible]
[illegible], Cape Town, South Africa

Paper 9635

Hendrik Muller

Designing a Predictable Train Service

CURRICULUM VITAE

Hendrik Adriaan (Heonie) Muller

Heonie Muller joined the South African Transport Services as a bursary student in 1976. He obtained the degree B.Com (Honours) (Transport Economics) at the Randse Afrikaanse Universiteit, and subsequently also completed a financial management course. He is currently a member of the Chartered Institute of Transport in Southern Africa.

In July 1982 he was appointed as Statistician at the Chief Electrical Engineer's office and was responsible for developing an internal Management Information System.

In 1987, he became a member of the management team which was responsible for the establishment of the Rolling Stock department in Spoornet. In this role, he functioned as Financial Manager and was primarily responsible for the implementation of a costing accounting system that placed the costing of locomotive and wagon utilisation on a sound basis.

In 1993 he was transferred to the Rail Operations department and in 1995 promoted to Assistant General Manager (Process Development). He spearheaded the Predictable Service initiative in Spoornet and is currently co-ordinating the development and implementation of the whole business transformation programme - which aims at addressing the client requirements and service quality.

INTERNATIONAL RAIL SAFETY CONFERENCE 1996

Title: *Designing a Predictable Train Service*

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Presentation Outline:

- *Introduction*
- *What is Predictable Service?*
- *Why Predictable Service?*
- *Predictable Service: How?*
- *Managing the business transformation*
- *Change Management*

Designing a Predictable Train Service

2 Sep 95

Introduction

This paper will deal with Spoornet's Predictable Service Programme - addressing the what, the why and the how of delivering a predictable service to its clients. It will also explain the role of Predictable Service in Spoornet's total business transformation; highlighting the approach and lessons learnt.

Spoornet, the largest division of the Transnet transportation company, is mainly a rail service provider. The eight billion rand division employs 58 000 people working in the freight business. Spoornet moves approximately 185 million tonnes of freight traffic annually for 1 700 clients across some 21 000 km of railway line using about 130 000 active wagons and 3 200 locomotives. The asset base is worth some twenty one billion rand. Spoornet essentially operates two types of freight businesses namely a coal and ore business (mostly export) and a general freight business (comprising a wide variety of commodities). This distinction is based on the inherent supply chain differences of a simple or high-inventory model and a just-in-time or low-inventory model.

Since 1990, Spoornet has undergone a major change - from being the country's dominant freight carrier to a public company in a deregulated market. Since the late 1980's statutory protection started falling away - enabling road hauliers with increasing payloads to directly compete with Spoornet. In addition, South Africa's recent re-entry to unimpeded foreign trade and the emergence of players with global corporate strategies have introduced new challenges with respect to becoming a transporter of choice in international logistic chains across many transport modes. Ninety percent of Spoornet's resources is currently involved in the highly complex general freight business where road truck operators provide strong competition as the consignment loads tend towards single truck loads. This market is totally deregulated with a maximum road-going gross vehicle mass of 57 tonnes per truck - compared to an average of 38 tonnes in the United States.

What is Predictable Service?

Owing to increased pressure experienced from competition and higher expectations of clients, Spoornet has of necessity been forced to reposition itself as a value-adding time- and place utility provider. "Consistently delivering the promise", as Spoornet's Predictable Service programme's credo, emphasises the orientation towards satisfying client needs. Delivering a predictable service essentially means agreeing and managing each consignment through its entire life cycle in accordance to the time and place promises made to the client.

Clients will experience a service delivery that conforms to all time appointments with pre-agreed time windows. Time utility means meeting four specific time appointments as agreed with the client for each consignment ("moments of truth") [illegible].

- T1: Placing of empty wagons in client siding at origin
- T2: Collection of loaded wagons from client siding at origin
- T3: Delivery of loaded wagons in client siding at destination
- T4: Removal of off-loaded wagons from client siding at destination

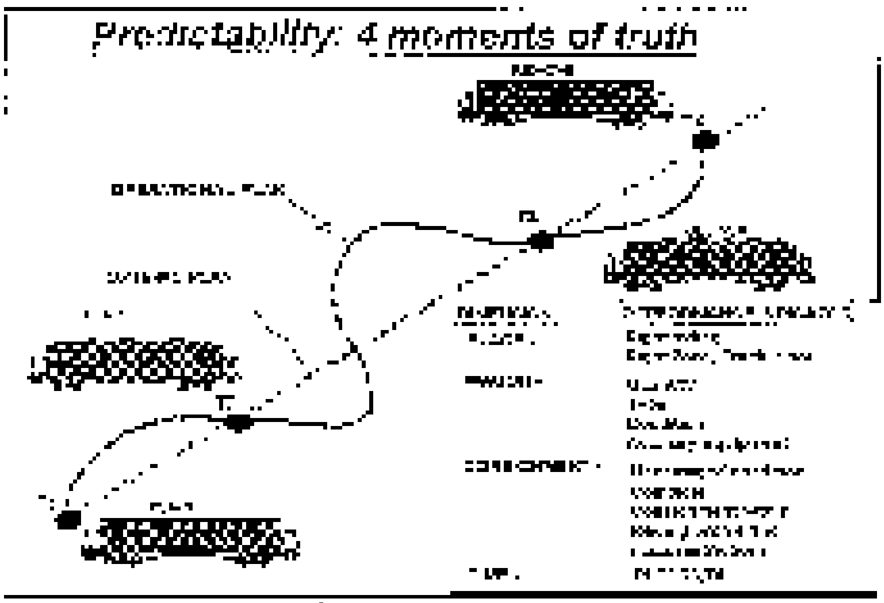


Diagram 7. Meeting four time appointments with the client

Service predictability is seen as the required core competency to turn the very complex and potentially profitable general freight business around. It revolves around the ability to plan the service in detail using a reservations system and to execute the plan accurately per consignment on a decentralised basis.

Why Predictable Service?

International market analysis indicates that the most important factor influencing freight transportation choice is a predictable and reliable service. To quote the late Mike Walsh of Union Pacific: "Research consistently shows that the chief issues driving customer satisfaction and retention are reliability, convenience of keeping the customer informed, quick and flexible responses to concerns about freight." Another survey of the transport industry in the USA [McGinnis, 1990] indicated that the four top client considerations that affect transportation choice are, in order of importance: transit reliability, on time capacity, transit time, competitive freight rates and minimum damage.

Recent local market analyses confirmed that predictability and reliability are the two attributes required from a South African freight transporter. The findings of a detailed market analysis of the logistics chain at the University of Pretoria corroborated those of an independent market survey conducted by BMI Insight during 1994 amongst more than 200 of Spoornet's current and previous clients. Both surveys found that clients are increasingly requiring a transporter to be very reliable with time predictability as one of the topmost concerns. The top client requirements, in order of importance, found by the BMI survey are:

- Competitive rates (value for money)
- Time predictability at destination (delivery)
- Time predictability at origin (collection)
- Correct wagons provided on time as ordered
- Cargo not damaged

Research International did another independent survey during 1995 amongst 647 rail freight transport clients which confirmed the premium placed on predictability. The key client considerations are:

- Delivery punctuality
- Speed of delivery
- Minimal losses / theft of cargo
- Minimal damage to cargo
- Communication regarding progress of consignments

The need for predictability is reiterated by the envisaged advantages for both Spoornet and its clients. Client benefits include:

- Better production planning and execution capacity
- Lower inventory levels
- Less operating capital required
- Client can use transport reliability as leverage to compete in world-class logistics chains
- Client will know when Spoornet cannot commit to a specific deal, but will be assured that everything Spoornet promises will be delivered

Some of the benefits for Spoornet are:

- Improved resource planning, leading to better resource utilisation
- Ability to determine required resource levels and eliminate excess
- Increased ability to pro-actively commit resources
- Spoornet will know what it can deliver and will only enter into such agreements
- Predictability and operational excellence goes hand in hand and forms the basis for greater profitability.
- Predictability is the first stepping stone towards achieving Spoornet's long term vision of providing freight logistics solutions

Predictable Service: How?

All consignments are reserved on a three-tiered national master schedule that integrates main corridor schedules, feeder schedules and shunt cycles. The schedule is corridor driven, which constitutes a move away from regionally based operations to through scheduling of trains on corridors that connect major markets. Each consignment is pro-actively reserved on a trip plan of connecting trains over all three tiers of the schedule. Reservations prompt the generation of works orders to local personnel to facilitate train building and shunting movements.

In the new Spoornet trains will be built according to works orders that are derived from reservations made on the national schedule - which implies that the old "push" operational philosophy is replaced by a "pull" philosophy. The client's requirements "pull" operational behaviour and train movement via the reservations mechanism. In the past Spoornet had a "push" operational philosophy, where we cleared sidings, built trains (filled them up with wagons) and pushed the trains in the direction of the correct destination without actively managing the time dimension of each consignment.

One of the critical success factors for ensuring that the delivery of a consignment at a specific destination is done on time, is ensuring that the train on which that consignment was reserved, indeed leaves on time, as planned on the national schedule. To ensure that every train departs on time, a count down procedure has been instituted for each train. Count down events and cut-off times are calculated for every train on the national schedule. This includes ensuring that enough of the required type of locomotives arrive well enough in advance, train crew signing, loco testing, train building, loco coupling, train inspection, etc. all happen at realistic pre-specified times to ensure that an 08:00 train can leave at 08:00 without delay.

Another critical requirement is that every consignment must make the connection with the right train, as reserved. This will be ensured if the yard personnel adhere to issued works orders, indicating which specific wagon numbers must be placed at and removed from every client siding during a specific shunt cycle. Works orders also specify to locomotive personnel which wagons must be detached and picked up en route by a main corridor train. Adherence to works orders is closely monitored.

The new operational philosophy, underpinned by reservations, places the operational process on a higher level than traditional tracking and tracing. The ability to re-reserve traffic that deviated from its original trip plan and to report expected ETA's of trains enables Spoornet not only to know where a consignment currently is, but also where it will be at specified future times. This provides an additional planning window to absorb and deal with contingencies.

Each consignment will be planned and will have a detailed individual trip plan. Each step in the consignment life cycle will be planned against a time line and executed and managed accordingly. The new operational modus operandi will be to: "Plan the work and work the plan". A central joint operations office (JOC) was recently put in place. This office is responsible for centralised planning, whilst ensuring decentralised execution. This office will co-ordinate the finalisation of each specific day's train service, the co-ordination of the required movement planning for planned trains, centralised empty wagon distribution decision making, and monitoring of the train service in order to manage contingencies and to design alternative plans in case of disruptions and deviations. Service predictability also requires a commitment from support functions (eg. Rolling Stock and Infrastructure) with the required reliability of assets. These support functions are also represented in the JOC to be able to manage and co-ordinate the impact of planned and contingency maintenance on operations.

Consignment and operational monitoring, is a critical element of achieving predictability, since it enables the management of each process step on a detail level. The diagram below depicts a number of typical key performance indicators used to monitor internal predictability.

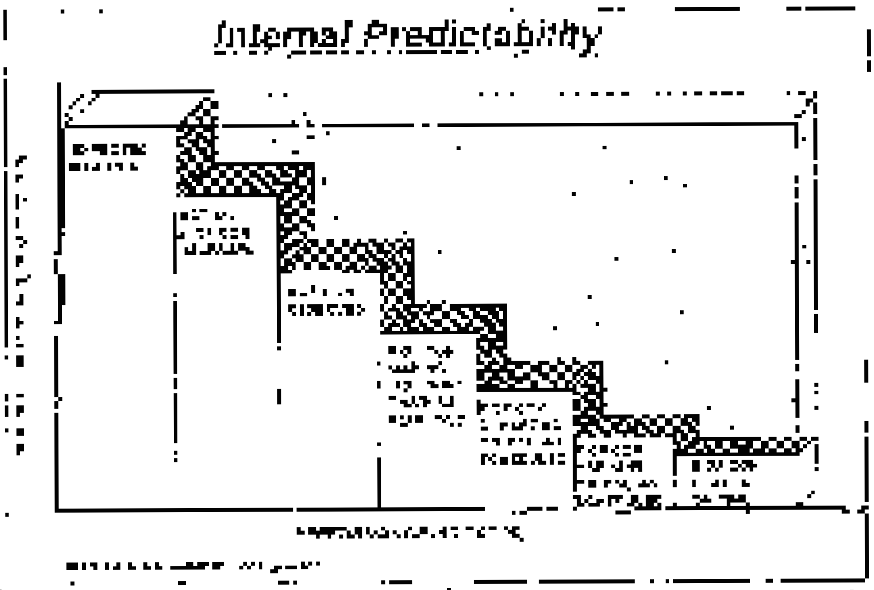


Diagram 2: Key performance indicators for internal monitoring

Some other important underlying aspects of predictability are the following:

- Ensures that operational events are captured accurately and timely in systems
- Ensures adherence to schedule (this idea implies ensuring that the schedule is realistic and derived from market demand, and that it contains enough flexibility)
- Closing of the gap between market demand forecasts and what physically transpires
- Ensuring that a client can receive and off-load traffic before it is dispatched (siding [illegible] planning)
- Pro-active reporting of exceptions to the correct target audiences (including clients)

The scope of Predictable Service can be summarised by three major phases:

- **Phase 1: "Plan the Work and work the Plan"** – Ingraining a time sensitivity culture by focusing on achieving 95% + of all TT's.
- **Phase 2: "Pro-actively committing resources"** – Ensuring that we don't promise what we cannot deliver.
- **Phase 3: "We only execute smart plans"** – Finding the most cost-efficient way to deliver all client promises.

In summary, one can say that Spoornet will still build and run trains as it did for the last 80 years – but instead of filling trains with wagons, trains will in future deliver consignments predictably using reservations on an integrated schedule that serves clients and market needs. The major difference is that every operational step happens against a time line in a pre-planned fashion. Every employee understands his/her unique role in this new operational process, and knows exactly when each step starts and when it ends be completed. Organisation-wide focus is now placed on reaching T0 – the most crucial moment of truth for the client.

The rest of the paper will deal with how the Predictable Service programme is managed. The business transformation approach is to address and alter the [illegible] value-adding business process, and to simultaneously effect the accompanying structural changes and the change management necessary to [illegible] people. It is a cross-functional programme that involves each role player, including Operations, Marketing, Rolling Stock, Infrastructure, Human Resources, Finance, Risk Management, Strategic Planning - as well as all regions and areas. Some of the more salient process changes are the following:

- Movement from a hierarchical and bureaucratic structure to a process driven organisation focused on client needs
- A client [illegible] process approach [illegible] train focus
- Demand driven operational plans versus capacity based schedules
- Commitment to time appointments made for acceptance and delivery
- Movement from a "push" operational philosophy to a "pull" philosophy
- Proactively controlling resources versus allocating resources reactively and on a contingency basis

Managing the business transformation: a process approach

The Predictable Service programme is managed from a process perspective. The value adding end-to-end business process constitutes the core of the whole business transformation. A common understanding of and buy-in into the core business process governs all change initiatives. Business processes are modelled on two levels - one describing the value adding activities, and the other describing the sequencing of activities and events. Process design according to the standards of the IDEF methodology ensures synchronised, hierarchical modelling of all process inputs, controls, mechanisms and outputs (depicted in diagram 3 below).

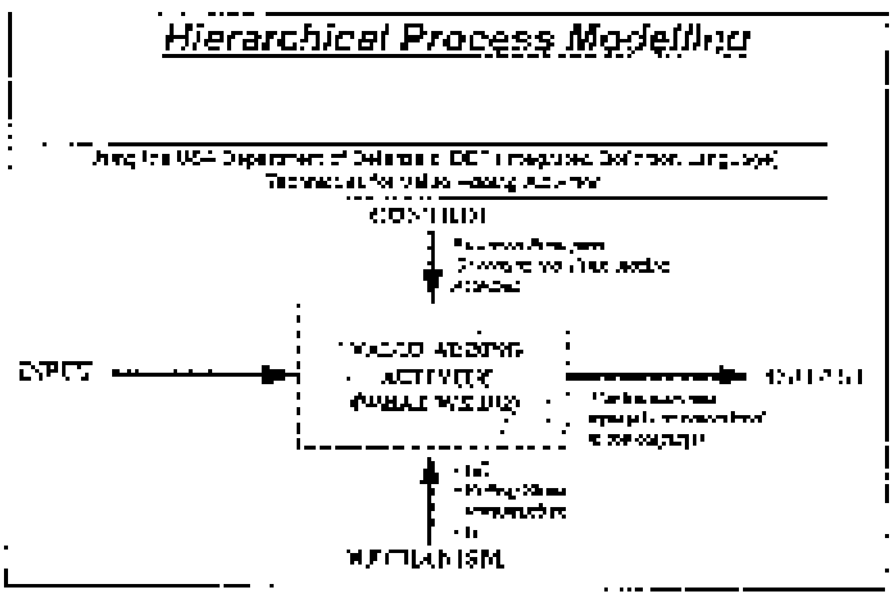


Diagram 3: Process modelling using the IDEF Methodology

The discipline of value chain process modelling (the "what" of the process) and work flow process modelling (the "how" of the process) forces all role players to understand and agree on the process domain, variables involved, relationships between variables, constraints, business rules and event sequencing assumptions to a sufficient level of detail. It thus creates a common nomenclature and well-defined Lego-type building blocks that can be re-used in and integrated with other related processes.

The value of a process driven approach is best explained by positioning its role in the business architecture. A new business architecture was developed for this large-scale business transformation. This architecture is an enterprise-wide, integrating framework which incorporates the following (as depicted in diagram 4 below):

- Strategic architecture depicting the interrelationships between vision, strategy, governance, principles and organisation design.
- Business process architecture governing development and documentation of value added process models ("what we do") and work flow descriptions ("how we do it").
- Resource architecture describing the role of people, technology and assets in processes.

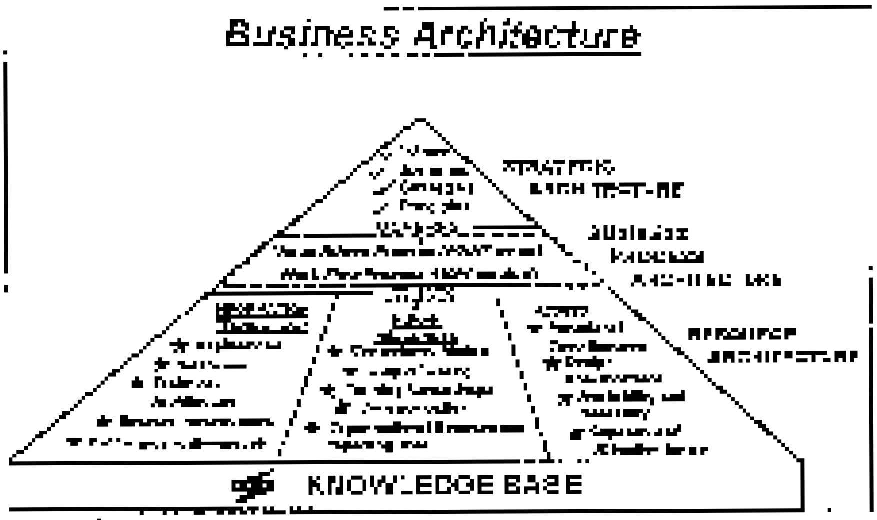


Diagram 4: Process driven business architecture

The end-to-end business process acts as the "glue" between vision / strategy and all resources (people, IT and assets). The process layer effectively translates vision and strategy into how and where which resources need to play which role in enabling the process. It indicates how people, IT and assets must be utilised to do client service business and to make money.

The business process architecture institutes a knowledge management discipline in Spoornet. It sends out the strong message that Spoornet is a process driven organisation. It also stresses the fact that functions can only add value to our clients if they are integrated with the core value adding business process (Year 2000 and beyond). The same process knowledge base is used to develop and manage new and current processes.

The chosen deployment approach is a process architecture. It indicates that all required system development and change management design should be derived from the business process. From a change management perspective all required competencies, training, training material, etc. needs to be traced back to process requirements. The same holds for IT design – i.e. software development, networks, database design, technical architecture, etc. Diagram 5 depicts the traceability of HR and IT efforts back to the process design.

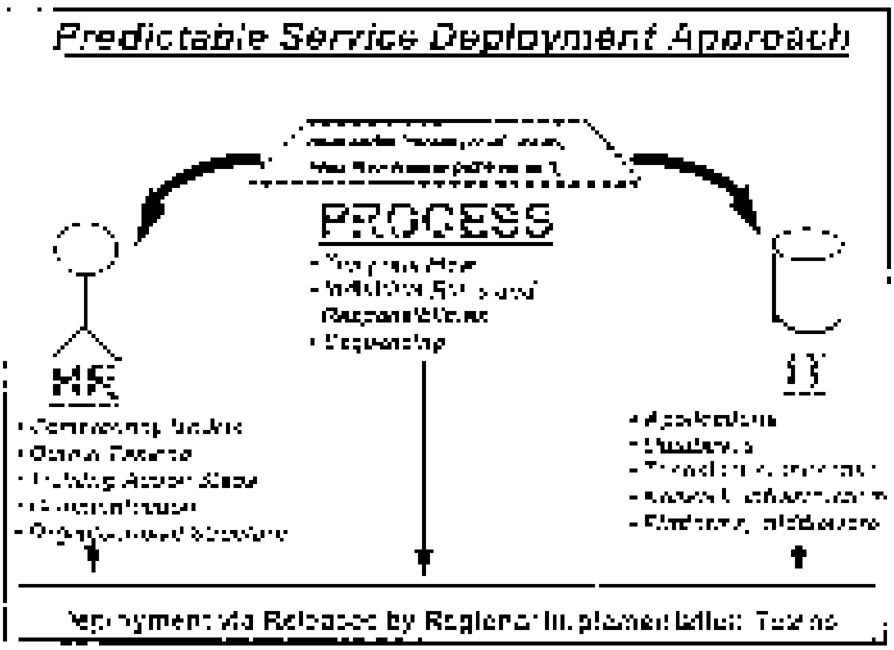


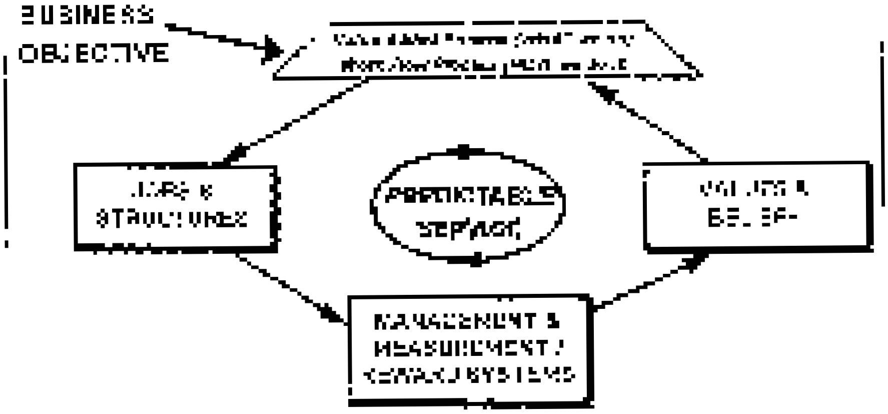
Diagram 5: *Process Driven Deployment Approach*

Change management

Across the process related initiatives, one of the main goals is to obtain commitment to Predictable Service throughout the organisation. Each employee needs to exactly understand his/her role in the value added business process. A new culture needs to be established where each employee understands what he/she must do and feel proud of his/her contribution. This is best illustrated by Michael Hammer's model (see diagram 6 below), which shows that the core business process also needs:

- Definition of job tasks (job specifications) and required organisational structures to make the process work
- Identification of required skills / competencies with relevant training
- Definition of relevant performance measurement norms
- Reward and recognition systems to reinforce the correct behaviour appropriately
- Also address people's value and belief systems – eg. to create greater sensitivity towards time and to create respect for one national production plan

Change Management: Impact on different business dimensions



Michael Hammer Change Management Model

Diagram 6: Different aspects of change management

Implementation of the Predictable Service programme will be done in releases, to ensure realistic, absorbable business change loops and the synchronised implementation of the required change management philosophy. Deployment is done by regional implementation teams, which consist of multi-disciplinary role players from different parts and functions of each region. The set of governing principles for all personnel will be the following questions each employee should continuously ask him/herself:

- Am I looking and planning ahead?
- Do I only sell what Spoornet can produce?
- Are all my promises to clients executable?
- Do I communicate promises made to clients to all role players?
- Am I living according to client promises?
- Do I address the causes of any deviations?

These will aim at attaining the required business culture in Spoornet.

The quest for predictability over the next few years will not only enable Spoornet to become a first-of-class rail operator and the transport operator of choice when logistics packages across modes are designed, but it will also enable Spoornet to play an active role in South Africa's reconstruction and development programme.

When Spoornet has achieved acceptable predictability performance, it can leverage off this operational excellence core competency to become the market leader in the provision of freight logistics solutions.

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Ho Chun Wing

Managing Human Factor in Practise

CURRICULUM VITAE

Ho Chun Wing

Train Services Manager, Hong Kong Mass Transit Railway Corporation.

As Train Services Manager, Ho Chun Wing is in charge of all train operators with a total staff numbering 522 in 1995. He joined Hong Kong Mass Transit Railway Corporation in June 1978, one year earlier than the official opening date of the railway for public service.

Since then, he has been working in the Operating Department (17 yrs). He has an extensive knowledge and experience in various aspects of the operational railway, viz. Station working, train operation, revenue collection (Automatic Fare Collection System), and the planning of new extensions etc.

Managing Human Factor in Practice

Ho Chun Wing   Train Services Manager

Hong Kong Mass Transit Railway Corporation

SYNOPSIS   This paper describes why, what and how the Operations of Hong Kong Mass Transit Railway Corporation contributes to manage risk with the participation of shop floor staff in a pragmatic manner and in turn to enhance the peak reliability of service in the railway in support of the Corporate Safety Management System which has been introduced since 1992.

The main process is to monitor and analyse continuously the trend of incidents with "human factor" as the root cause and build up a database of these happenings. From the information obtained, we then examine ways and methods how we can prevent and reduce these incidents through the change in equipment, working procedures and training, etc. in light of the best operational practices successfully adopted in other railways or through benchmarking.

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1. Introduction

In this paper, initially, I shall briefly talk about what my company, Mass Transit Railway Corporation in Hong Kong, has done on safety management. Subsequently, I shall specify in more details what other specific issues that my Train Staff Section, as a line department, has worked on in support of the safety management system in more practical terms for the sake of minimizing incidents and accidents and towards continuous improvement and excellence.

In the following context, my presentation will cover the following areas:

- A brief description of the Safety Management System; probably, most of you might have already heard about this in details in this Forum yesterday as presented by my colleague, Mr George Lee. Therefore, I would just like to brief members here what we have done in this direction in a broad term.

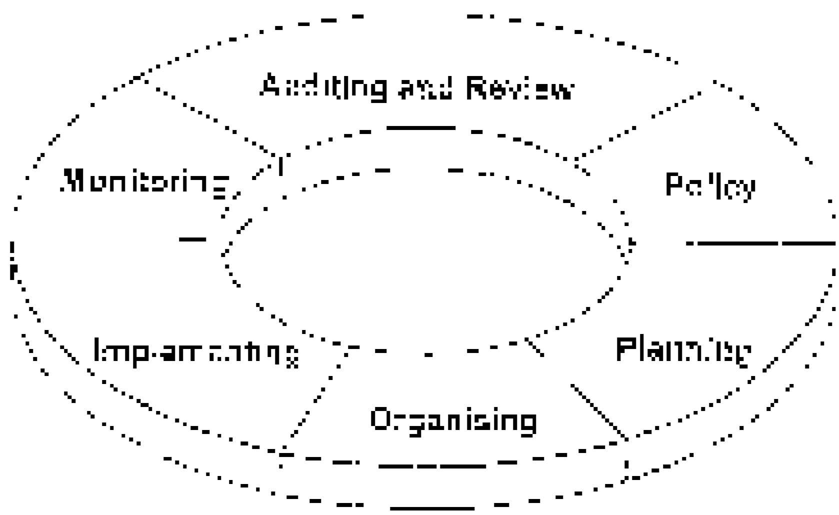
- We also conducted an ergonomic study of the driving cab through a Consultant two years ago. Some interesting findings were then identified with some useful recommendations for us to pursue. Most of the items related to ergonomic issues will be taken on board in the MTR Train Modernisation Project which will commence from 1998 until 2000.

- My main part of this paper will touch on what we have done in identifying the root causes of "human error" incidents and see how we could come up with some useful measures or initiatives through the participation of the shop floor staff in minimizing these kinds of incidents or accidents.

2. <u>Safety Management System</u>

Safety Management System has been introduced in our company since 1991. The purpose of the Safety Management System is to provide a management tool as well as a workable framework for line managers to manage safety, like any other issues such as finance, operations, human resources in the same manner, in a systematic, proactive and consistent manner so that the MTRC Safety Policy can be effectively implemented.

The process cycle is as follows:



Key components of the Safety Management System are:

- MTRC Safety Policy
- Safety Tasks and Safety Modules
- Safety Management Process
- Safety Responsibility Statements
- Safety Audit System
- Risk Control System
- Safety Critical Systems/Operations

3. Ergonomics Study of the Driving Cab

A study was commissioned sometime in 1993 and conducted by an external consultant firm, viz. W S Atkins.

In brief terms, I quote what have been mentioned in 'Executive Summary' the findings and the recommendations as below:

Findings

The results of the study suggest that current duties of Passenger Train Operators are monotonous and make few demands on their abilities during normal running, whilst requiring high level of skill in resolving defects or incidents. Average workload is below minimum satisfactory levels and the low level of running duties allows little opportunity to refine skills and engenders a sense of isolation. In addition, the ergonomic assessment of the train cab has revealed a disturbing number of significant design deficiencies.

Recommendations

Recommendations have been proposed to improve the cab design, the organization of the Passenger Train Operator's duties, training, communication aspects, team working and career development. Implementation of these recommendations will result in improved workload levels, in addition to an increase in staff morale, leading to more efficient and safer railway operations.

As mentioned in the introduction, all issues identified have been either followed up or would be taken on board with our EMU Modernisation Project commencing in 1998.

4. Selection Tests for Train Operators

Two years ago, upon the recommendation from an external consultant, Kaiser, we first introduced some selection tests to identify applicants with suitable personalities so as to perform the role of a train operator.

The reasons for such selection process are twofold:

- To identify suitable persons for the job
- To reduce unnecessary wastage of our training resources

The following tests will be taken by the applicants and they are:

(a) <u>Complex Test (DTC)</u>

The main objective of this test is to check response and to give insight into how the candidate performs under pressure created by different visual and acoustic stimuli.

The DTC is a choice reaction and co-ordination test in which candidates are required to react quickly and accurately to a number of visual and colour light signals, tones and requires reactions with pedals or levers simulating the driver's position.

This is a timed test lasting for about 10-15 minutes.

Constraint: This test is subject to 'time of day effect.'

(b) Group Bourdon

The main objective of this test is to check concentration.

This is one of the two safety tests (DTC is the another one) which assess whether candidates possess the qualities necessary to meet the safety requirements of the position. In particular, these two tests examine the candidates' power of observation, concentration, attention to detail, alertness, reactions, co-ordination and ability to cope under stress.

The Group Bourdon is a concentration test. It is designed to measure a candidate's ability to sustain attention and concentration which he/she will have to do when working alone for long periods of time and when under training.

Candidates are required to complete accurate, detailed and repetitive task.

This is a timed test lasting for 10 minutes.

(c) <u>Neo Personality Inventory</u>

The NEO Personality Inventory provides information on five dimensions:

Neuroticism -	the extent to which a person is prone to anxiety and worry
Extraversion	the extent to which a person demonstrates traits such as warmth, assertiveness, sociableness
Openness	the extent to which a person is open to new experiences

Agreeableness - a measure of people's orientation towards other people

Conscientiousness - the extent to which a person is business like, persistent, scrupulous and reliable

The NEO-PI-R consists of a series of multiple choice questions about the way in which an individual prefers to act, behave and feel.

This is not a timed test. People usually take 30-40 minutes to complete the questionnaire.

(c) <u>FIRO-B</u>

This questionnaire provides information about an aspect of one's relationships with other people on three dimensions:

Inclusion - their preference for spending time with others or being alone

Control - their preference for taking control and responsibility or being guided by others in what they do

Affection - their preference for having close and intimate or distant relationship with others

Respondents are asked to complete a series of multiple choice questions relating to the dimensions outlined above.

This is an untimed questionnaire. Respondents usually take about 10 to 15 minutes to complete it.

(d) Verbal & Numerical Ability Tests

These are timed tests with time allowed of 35 minutes.

3. Some Background Information about the Organisation – Train Staff Section

Establishment of Train Staff Section

All staff are responsible for the train operation, including passenger trains and Engineer's Trains.

There are all together 527 persons, out of which 332 are Passenger Train Operators and 62 are Maintenance Link Train Operators.

Types of Trains Being Operated

EMU Passenger Trains

Engineer's Train formed with Diesel Locomotives or Battery Electric Locomotives with wagons.

<u>Mode of Operation</u>

For our passenger train operation, the signalling system is Automatic Train Control (ATC) with Automatic Train Protection (ATP) and Automatic Train Operation (ATO). In most of the situations [illegible] automatic mode.

6. <u>Human Factor in Practice and Application</u>

6.1 Why do we need a Human Factor Working Group?

Just now, I have talked so much how we are addressing the safety management system. Although noticeable improvements have been made in various areas in term of performance, say, the safety culture, safety awareness and the number of [illegible] incidents with human error as the root cause continue to happen.

In the following context, I shall explain how we tackle this subject with the participation of the shop floor staff and the experts to see how we can reduce and minimize incidents and accidents in the railway. I have explained why we need a Human Factor Working Group.

6.2 Formation of Human Factor Working Group

The working group consists of the following persons:-

One Manager to lead the group

Other members are:

2 Supervisors

4 Train Operators

1 Representative from Human Resource Management Department

1 Representative from Training Centre (School)

1 Representative from Safety Services Department

6.3 <u>Scope of Human Factor Working Group</u>

The scope of this working group is:

- To continue in monitoring, analysing the trend of incidents with "human factor" as the root cause and build up a database of [illegible].

- To maintain statistics and charts on monthly basis to monitor the trend.

- To continue in examining ways and methods to prevent and reduce these incidents through the change in equipment, working procedures and training, etc. in light of the best operational practices currently adopted in other railways or through benchmarking.

- To provide assistance and guidance to staff on how to perform [illegible] so that incidents involving "Staff Error" can be minimised and avoided.

- To enhance the commitment and morale of shop floor staff through their participation and contributions.

- To aim for continuous improvement in customer service through the effort of the working group.

- To reduce the average rate of incidents caused by human errors by 10% on yearly basis.

6.4 <u>Classification of Incidents with "Human Error"</u> as the root cause

In general, all incidents with "human error" as the root cause were analysed and then classified into two main categories with due regard of their impacts on "Safety" and "Services".

6.5 Safety Issues

Through analysis of data, [illegible] we are able to identify the main items of concern but also can focus our attention to direct our resources to deal with them. For those items that might bring about serious or potential serious damage to equipment or cause injury to staff or passengers, we classified them under items of "Safety" as below and listed a short account in more details later.

- Signal Passed at Danger

- Train Hitting Buffer Stop

- Train Doors Wrongly Opened when Stop Short at Station

- Others

6.6 Services Issues

For those items that will bring about service delay with minor or without damage to equipment or causing any minor injury to staff and passengers, we then classify them as items of "Services". In comparison with those "Safety" items, they are only minor in nature. Therefore, I would like to give you a quick glance on the items and will not dwell on such details.

- Kept Open Door Not Close
- Failing to Pick Up Train
- Failing to Operate/Bypass Train in Proper Manner
- Failing to Stop/Mistakenly Pick Up Passengers
- Passengers Overcarried
- Failing to Inform/Contact Control for Physical Need Relief
- Others

7. Signal Passed at Danger

7.1 What have we done?

Every time when we have an incident of "Signal Passed at Danger", we would acquire the following data or information for analysis and they are:

- Long Working Hour/Shift Pattern
- Influenced by Drug or Alcohol
- Personal Stress or Family Problem
- Personal Health and Fitness
- Equipment Fault
- Procedure Deficiency
- Training and Knowledge
- Lapse of Concentration
- Communication Breakdown
- Visibility

7.2 Study on the Location of Signals

As it was noted from members of working group that there might be problems related to the locations of some signals that would lead to accidental cases of "Signal Passed at Danger", a very thorough study was then conducted through the joint effort of some colleagues.

At the end of the study, a very detailed study report was submitted with some recommendations on the change of the locations of some signals. After further review by colleagues of Operations Engineering Department, these recommendations have been accepted with changes implemented progressively.

7.3 British Rail Research on the Working Hours Related to Safety

With the assistance from my colleague, Mr George Lee, I had a chance to read the said report as presented by Mr David Whittle-Stead, Human Factors Adviser, British Railways in this forum in [illegible].

I did a quick recap on the findings as a note of interest to our organisation as below:

"No increase in safety risk when working up to 12 hour shifts, high levels of weekly hours, or long runs of consecutive shifts without a break.

Safety risks were not found to be influenced by age, type of work, or variability in shift start times.

A clear pattern in the relationship between hour-in-shift and safety emerged. There is a peak in the risk of an event occurring in the 2nd to 4th hours of the shift, followed by a gradual decrease in risks up to the 12th hour.

There are some indications, however, that the risks may be greater for those working fewest weekly hours and on first returning to work after a period of [illegible]."

Based on the findings of the said report, we then carried out a similar analysis with our data on hand. However, we were unable to establish any correlation between the following factors and the causes of incidents:

- length of service of train operators
- length of duty hours
- meal breaks
- sick/long leaves

The main reason why we cannot come up with any relationship was that we were lacking sufficient data for us to draw any general set of conclusions.

We might repeat the same process one or two years later and perhaps, by that time, we might have more data for analysis.

7.4 Our Study and Analysis of Data

After our study and analysis, the initial causes of "Signal Passed at Danger" incidents were:

- Lapse of Concentration (62.5 %)
- Inadequate Knowledge (29.2 %)
- Others (8.3 %)

A breakdown of the causes is depicted in Appendix I.

7.5 Our Findings and Initiatives

Given the findings, we then reinforced our effort on training and job knowledge. However, this was something we believed that we were missing, but we did not know what it was. Only until a recent incident which happened on [illegible] December [illegible] and caused a lot of attention from the publicity and media, then it appeared that we were able to identify the root reason behind why people failed and led to incidents in our working environment.

7.6 Road Sense

I do not want to bore you with details of the incident. Instead, I would like to tell you what we have learnt from this incident.

In our system, trains are driven in Auto mode almost all the time. Only when we have problems or faults with the ATP/ATO equipment, we then would switch to manual working. The chance of encountering such is about 2% in accordance with our statistics.

Given such working conditions day in and day out, in the event when our train operators are required to drive trains manually without ATP protection, they may neglect to watch out the important things at the outside road conditions, say, the signal, the point position, etc. before they start to move the train in manual mode or during the train movement, in particular, when they are under the time pressure to achieve a recovery as soon as possible.

Very often, their attention is bound by the internal environment of the driving cab, say, to watch out the speedometer to make sure that the train will not be overspeed [illegible] as the maximum allowable speed in restricted manual mode is 22 kph.

From our study of this incident, we came up with an interesting finding which we call "road sense" as what we do when we drive our cars on the road.

From this finding, we develop a series of activities to educate our train operators to pay attention to this important element.

More information on how we promote the importance of "road sense" is depicted in Appendix 2.

With the introduction of "Road Sense" concept, we are greatly sure that we can further reduce the incidents of "Passed Signal at Danger".

7.7 <u>Statistics on the Incidents of Trains "Passed Signal at Danger" in 1993-1996</u>

The figures of the incidents of "Passed Signal at Danger" in 1993-1996 are depicted as below.

Type of Incident	1993	1994	1995	1996 Jan-May
Signal Passed at Danger	1	14	7	3

8. Train Hitting Buffer Stop

8.1 <u>What have been provided at the buffer stops on site to warn the train operators?</u>

The standard provision is that two fixed red lights are mounted on top of the buffer stop to remind the train operator their existence.

8.2 <u>Our Study and Analysis of Data</u>

Initially, the apparent root cause was lack of concentration on the part of the train operator. How could we help our staff to reduce this error? At the early stage, we did not have any clue at all. However, there was a common feature that most of these cases happened at depots.

Only after we had collected more data from the incidents, an interesting finding emerged related to the working practice.

It has been a deep-rooted habit that whenever vehicles be stabled on a track at depot, the train operators will place them as close as possible to the buffer stop. In the old days, there was a valid reason to do this as more space of the track could be spared out for other uses.

8.3 Our Findings and Initiatives

After further analysis by the working group, it was concluded that there was no such need any more now. Therefore, a new procedure was devised: vehicles must normally be placed away from a buffer stop by at least 4 metres with the stopping mark painted yellow in colour to remind the train operators.

In the case if vehicles have to be placed close to a buffer stop, if necessary, the movement should be supervised by a Supervisor and the speed should be maintained at a dead slow speed.

After the introduction of the new working practice, very marked improvement has been noted.

8.4 Statistics of Incidents of "Train Hitting Buffer Stop"

The figures of incidents of "Train Hitting Buffer Stop" in 1993-1996 are depicted as below:

Type of Incident	1993	1994	1995	1996 Jan-May
Train Hitting Buffer Stop	3	6	1	0

9. Train Doors Opened Wrongly When Stop Short at Station

First, let me explain what one means by this term: In Auto mode, there might be chances that the trainborne computer fails to pick up the trackside information from the XX marker en route for station stopping and therefore, the trainborne computer will, through its own logistics, recalculate the distance to the next station stopping mark. Occasionally, there might be a variance in the calculation, therefore, the train might stop short by a few metres from the correct stopping mark, resulting the last pair or two pairs of the train doors of the last car still inside the tunnel.

If the train operator does not check carefully before he/she opens the train doors, a hazardous situation may develop such that a passenger(s) might fall onto the track.

9.1 What have we done?

Again, some data have been collected on the occurrences of this kind of incident and the finding could again be traced to the lapse of concentration.

9.2 Our Findings and Initiatives

Further analyses reflected that apart from the cause of the lapse of concentration, there was something to do with the marking of the stopping mark on platform.

Our initiatives were twofold:

- Labels were placed in the driving cab to remind train operators to check the stopping mark before they opened the train doors after a train came to a stop on platform.
- Stopping marks were re-designed to be bigger and more conspicuous on platform.

Since the introduction of these, there has been no more report of train doors wrongly opened when stop short at station.

9.2 <u>Statistics</u>

The figures of incidents of "Train Doors Wrongly Opened at Stop Short" in 1993-1996 are depicted as below:

Type of Incident	1993	1994	1995	1996 Jan-May
Train Doors Wrongly Opened When Stop Short at Station	2	9	10	0

The consolidated figures of all "Safety" items in 1993-1996 are depicted in Appendix 8.

10. <u>Services Issues</u>

On these issues, what I would like to show you is the year-on-year performance in 1993-1996 with figures as depicted in Appendix 9. Here you will notice that we are able to obtain continuous improvement progressively.

11. <u>Conclusion</u>

Through the set up of the Human Factor Working Group, not only useful ideas could be generated in helping us in identifying the root causes of some incidents involving human factors at the angle of the end-users, but also high commitment and morale from the shop floor staff could be maintained. Moreover, when new initiatives be derived and implemented, staff would find this more convincing and acceptable to them through their participation and consultation.

Appendix 1

A Cause Analysis of Signal Passed At Danger

[24 cases in 1995 & 1996 (Jan-May)]

Cause	No. of occurrence
Long Working Hour / Shift Pattern	0
Influenced By Drug or Alcohol	3
Personal Stress or Family Problem	0
Personal Health And Fitness	0
Equipment Fault	1
Procedural Deficiency	1
Inadequate Knowledge	7
Lapse Of Concentration	15
Communication Breakdown	6
Visibility	0

Appendix 2

Improving Road Sense Amongst Train Operators

1. **Introduction**

By means of "road sense", we interpret that before a train moves or in the course of driving, a Train Operator be able to remain conscious and attentive to things either happening or existing outside the driving cab on the track and hence be able to make the appropriate judgement to react promptly to avoid accident.

2. Road Sense

When the train is required to be operated in Restricted Manual mode, it is no longer protected by ATP. Hence, it is imperative that every train operator has to exercise a high level of "road sense" in order to avoid any untoward incident or accident.

As a reminder, I would like to reiterate the essence of "road sense" as follows:

2.1 Before making any attempt to move in Restricted Manual mode:

A train operator must :

- check for necessary authorization and the limit of movement.

- check for a safe route condition by looking at the track in front to ensure that any point(s) ahead is correctly set to the intended route.

- check for correct proceed signal or handsignal.

- check for acquaintance with the intended route, destination and stop(s) en route.

2.2 During the course of driving:

A train operator should:

- Be attentive and maintain a good lookout on the road at all times.

  Watch out for signals, points and crossings.

- Be conversant with the special workings of train, such as RM, CM, speed limit.

- Be aware of motoring and braking performance on abnormal road surface.

  Be prepared for any untoward occurrence on the road.

- Stop when in doubt and follow the process of "Think Check Do."

3. **Activities and campaigns**

As mentioned above, the possession of good road sense is considered as one of the essential qualities of a train driver. Therefore, aiming at enhancing the level of road sense amongst train operators, a series of activities have been planned to occur as monthly events in the Train Staff Section.

The tables below summarise the planned activities.

Month	Format/Content	Medium
Feb	RM discussion seminar	Classroom Discussion
Mar	Practical exercise in Depot	Practical Driving
Apr	Educational messages and cartoons	Train Staff News
May	Inserts completed with sound track in TV programme	Mess Room TV
Jun	Slogan competition	Open Competition
Jul	Educational messages & games in a Depot-Day gathering	Speech & Game
Aug	Crossword puzzle competition	Train Staff News
Sep	Inserts completed with sound track in TV programme	Mess Room TV
Oct	Operating Safety Quiz	Quiz Competition
Nov	Safety & Customer Service video	Mess Room TV
Dec	Messages from Managers	Train Staff News

Long term and Continuous Programme
1. To incorporate some questions in the CBT software
2. Training Unit to include a 'Road Sense' topic in SOD/OJT training
3. Mandatory questions in annual R&F examination
4. To incorporate in New Recruits and Refresher Course training programme.

Consolidated Figures of Safety / Service Issues

Type of Issue	No. of Occurrence			
Safety Issues	1993	1994	1995	1996 Jan-May
1. Train Passed Signal at Danger	[illegible]	4	[illegible]	[illegible]
2. Train Hitting Buffer Stop	[illegible]	6	[illegible]	[illegible]
3. Train Doors Wrongly Opened When Stopping At Station	[illegible]	9	10	0
4. Others	5	[illegible]	23	6
Service Issues	1993	1994	1995	1996 Jan-May
Cases affecting Service	[illegible]	[illegible]	[illegible]	[illegible]

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Future Organisation of Operations Safety Units Deutsche Bahn AG

CURRICULUM VITAE

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Assistant Manager in the Chief-department for operations safety, and Deputy of Chief Manager Dipl.-Ing. Dieter Metz.

Supporting functions and experiences in tasks of updating rules and regulations for operational safety

Member of a project group:
Development of structures for operational safety offices

International Railway Safety Conference 1996

Future Organization of Operations Safety Units
Deutsche Bahn AG

Dieter Reuter
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I

The Deutsche Bahn AG installed a new organizational concept as of January 1, 1994; the corporation is now structured largely by divisions.

Among the functions assigned to the Rail Division, itself a profit center, are the maintenance of the rails and their operation.

As regards safety, the legal mandate is clear: The operations are to be run safely; the railway infrastructure and rolling stock are to be engineered and built for safety and kept in a safe condition.

It is a well-known fact that railways are high-precision operations and that recognized and accepted safety standards are the indispensable basis for this precision.

Constant monitoring of safety rules is an executive-level task in railway operations. Rules which are routinely disregarded without sanctions being imposed or will be degraded and ultimately lose all value — no matter how meaningful they might be.

Safety audits are conducted at the Deutsche Bahn AG to examine and evaluate the application and effectiveness of safety-related rules for operational processes. Supervisors have a legal obligation to select their employees carefully, to instruct them in their work and to supervise their activities. In so far assignments, responsibility and authority are to be defined by corporate management in each case, right down to those who do the actual work in the field.

II

The Network Division of the Deutsche Bahn AG will introduce a new, fully documented organizational and operational structure in two stages as from January 1, 1997. An integral component will be the "Operational Safety" management system, developed for the Deutsche Bahn AG with the support of experienced corporate consultants, Unternehmensberatung GmbH Dr. ADAMS UND PARTNER in Duisburg. It is against this background that the fundamentals of the concept for the Operational Safety Management System are described below.

The obligation to run the system safely can be satisfied only if the divisions implement the organizational concepts which that obligation implies: this is illustrated by way of example for the Network Division (Chart 1).

Consequently the tasks and appropriate authority must be assigned to the line organization and to the advisory organizational units (Chart 2).

To be found in the line organization are all the executive and implementing units at the particular level in the hierarchy. Responsibility for operational safety is situated here. The degree of operational safety within the tasks to be carried out will be decisively dependent on how much influence the particular function has on it.

Tasks and authority must also be assigned to the advisory organizational units which do preliminary and back-up work — advising, supporting and monitoring the line units.

Decisive in this context is proper arrangement of cooperation between the line and advisory units (reporting requirements and whether information is to be supplied spontaneously or upon request by the recipient, etc.).

II.

The goal is a two-level business structure in the Network Division: branches and the central administration.

The branches are responsible for operating the infrastructure. The branches are managed as profit centers and are evaluated using profit calculations derived from route revenues and operating expenditures. Converging in the branches are all the operator's functions associated with the network infrastructure. Five operating locations will be established within each branch to carry out operational assignments.

The branches will be managed on the principle of collective responsibility; a management spokesperson shall be designated. Branch management consists of the managers for sales, infrastructure, controlling and personnel along with the managers of the operating locations.

Specialized know-how for assignments in plant planning and project implementation will be concentrated in separate organizational units (network services attached to headquarters, with field offices).

A performance chart will be drawn up for each branch (Chart 3).

* Sales is responsible for sales, customer care and route management.

* The task of the infrastructure unit is to design an optimized network infrastructure in regard to capacities and costs.

* There are performance charts for controlling and personnel management.

* Included in the performance chart for operations are the following core assignments:
  — Planning and carrying out operations and maintenance
  — Ensuring uninterrupted conduct of operations and availability of the equipment at harmonized quality,
  — Coordinating construction and operations
  — Scheduling operations
  — Planning and carrying out emergency management
  — Power network operation management (15,000 V).

IV

The specialty office for operational safety of the branches has an advisory and supporting function. The core assignments for the operational safety office are:

* Supporting the preparation and updating of the rules for operational safety and providing advice in interpreting operational safety regulations

* Laying the groundwork for decisions
  ⊗ whenever branch management must approve variances from the operational safety regulations
  ⊗ in case of conflicts in the interpretation of the operational safety regulations.

* Monitoring the maintenance of operational safety
  ⊗ organizing and conducting safety audits as well as initiating the elimination of recognized weak points
  ⊗ organizing the monitoring of safety supervision, evaluating the results and initiating the elimination of recognized weak points
  ⊗ organizing special monitoring campaigns and reporting on the results

- Initiating efforts to improve operational safety, examining the plausibility of investigation reports on railway operational accidents

- Providing technical support to persons charged with regular and recurrent in-service training

- Conducting risk analyses for processes impinging on operational safety and working out risk evaluations

- Developing and updating communications concepts for operational safety (safety culture)

- Coordinating contacts with government authorities, associations and the like in regard to operational safety matters.

- Cooperating with the specialty office of the Network Division and the specialty offices of other divisions in operational safety matters.

- Organizing within the job order forwarding process routines for identifying safety matters which impact multiple divisions

- Conducting success checks for efforts which are a part of the safety program and working out contributions to the corporate management safety report

V

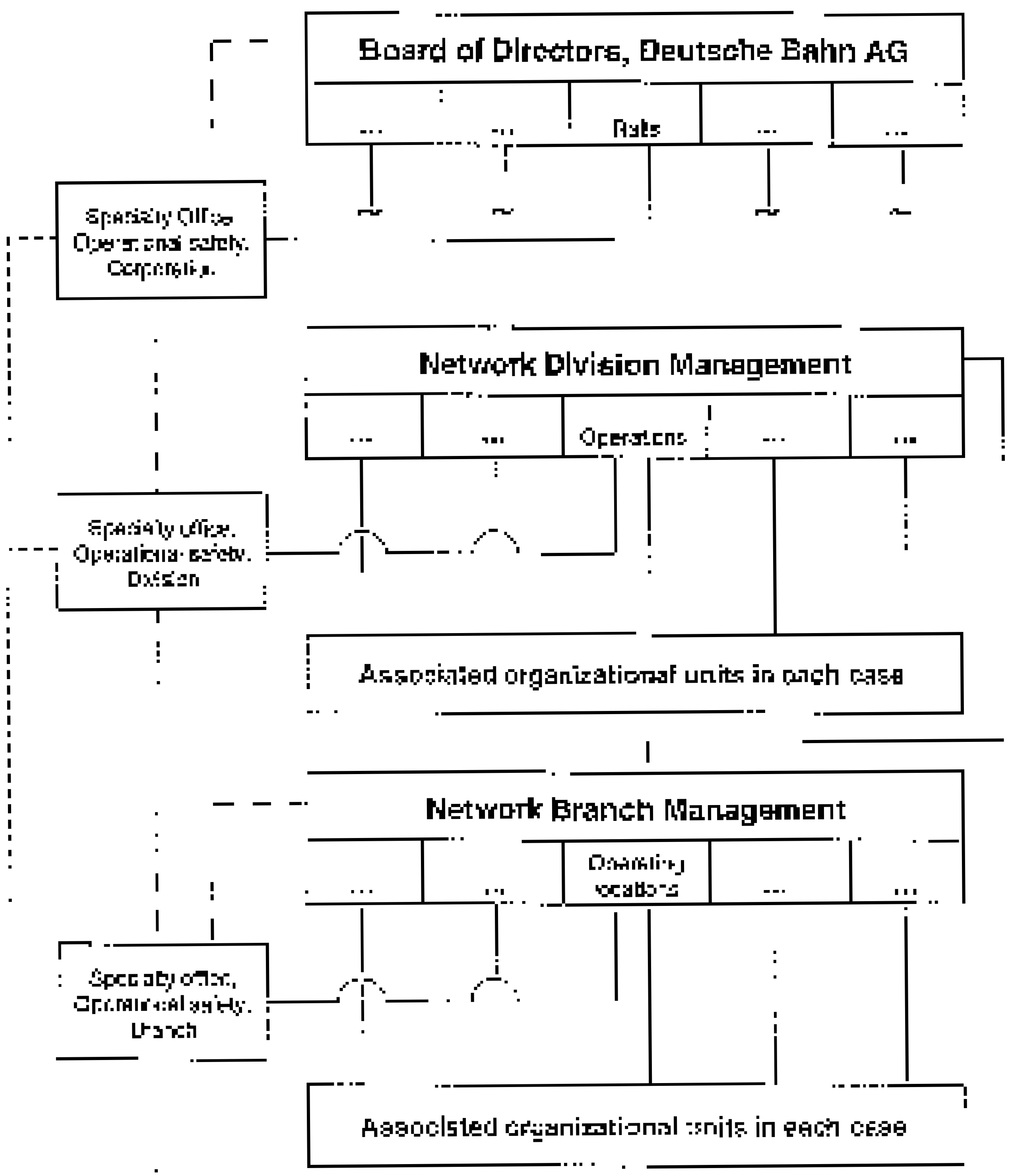
Of prime importance is the clear delineation of assignments between the line organization and the specialty offices.

The specialty office for safety has basically no authority to issue orders to the line organization in the branch.

Effective cooperation will be achieved by integrating the other safety-relevant management systems.

Thus the goal is coalescence with the management systems for environmental protection, occupational safety and quality (Chart 4) already in place within the Deutsche Bundesbahn AG. It must never be allowed to happen that only after an accident is safety propelled to the top of the agenda, then dominating thinking or public opinion. The *leitmotif* is: safety through integration.

Organizational Concept in the Network Division

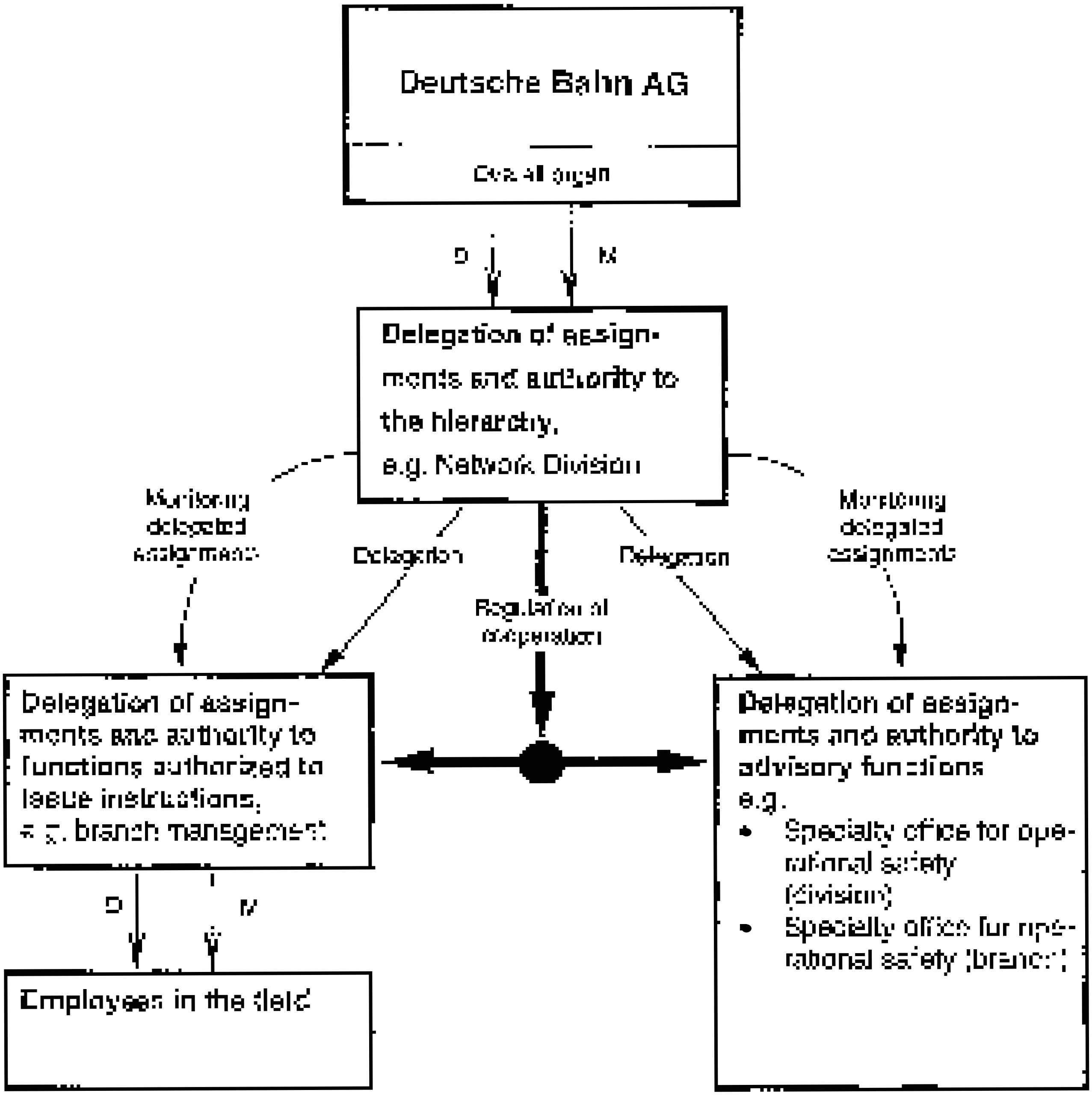


Legend:

— — Cooperation, consulting, monitoring

\- - - Inter-divisional tasks in the ... forwarding process

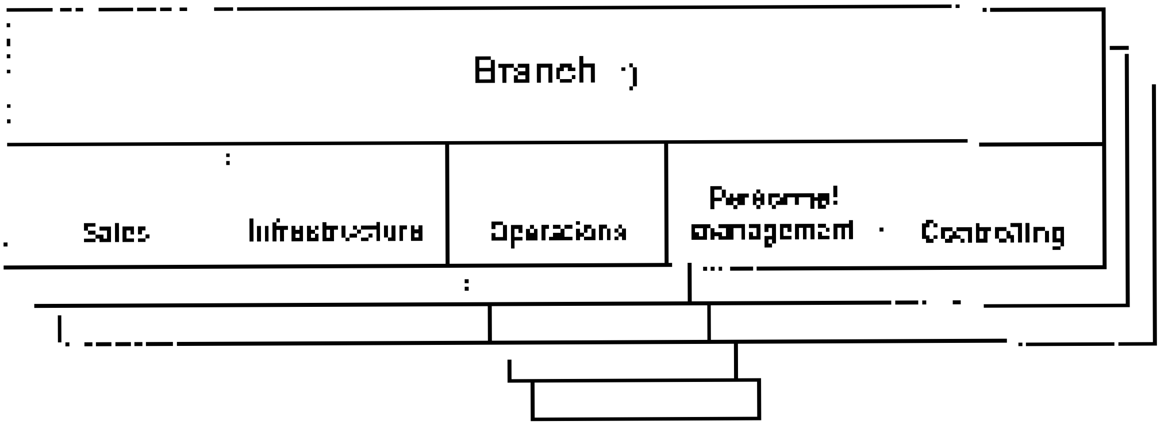
Organizational obligations for the division



Legend:

D = Delegation
M = Monitoring

Performance chart: Branch

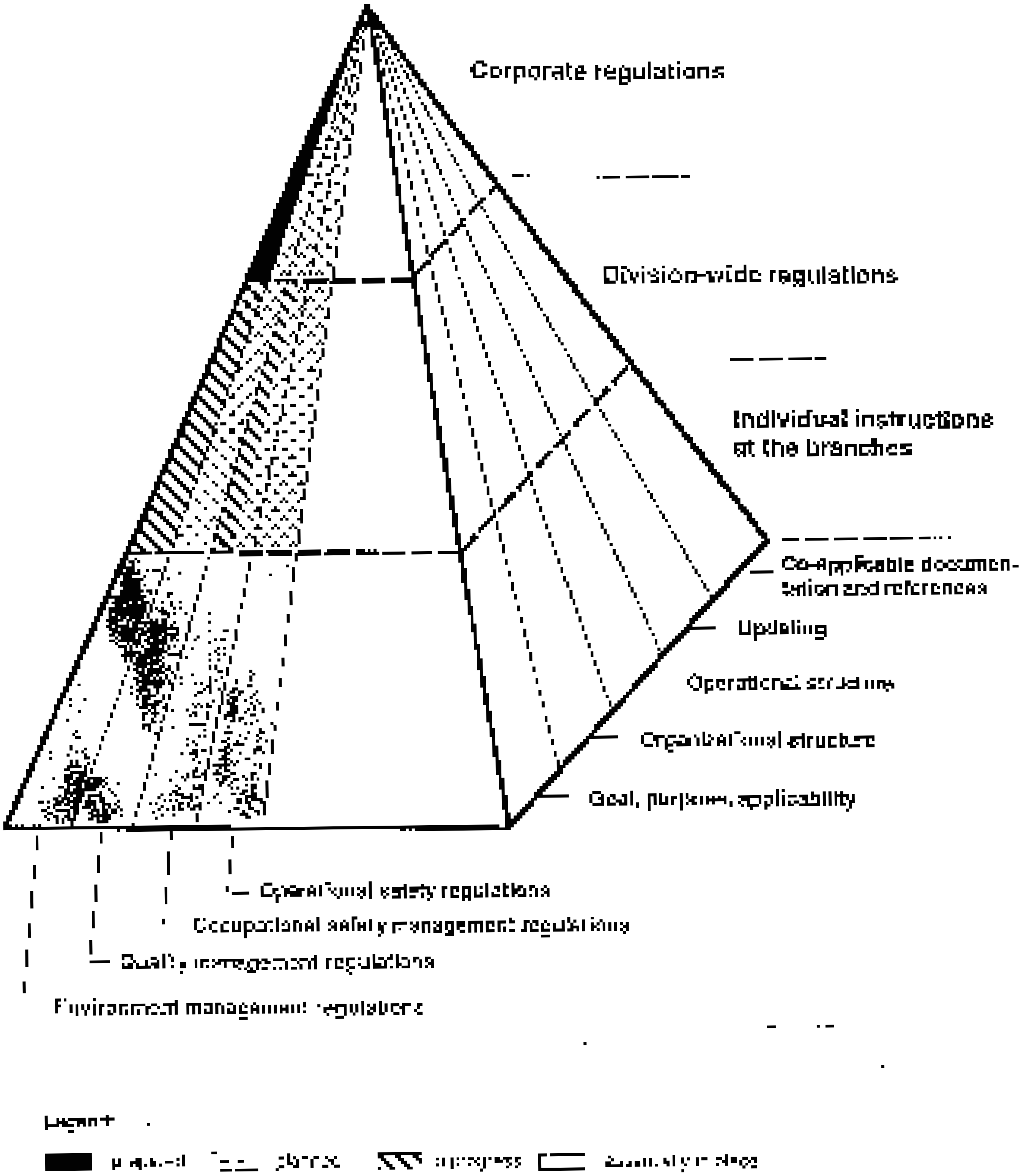


Operations	NNB

- Planning and carrying out operations and maintenance
- Ensuring conduct of operations and availability of plant at agreed quality level
- Coordinating construction and operations
- Scheduling operations
- Planning and carrying out emergency management
- Carrying out power network operation management (15 KV)

*) 7 branches
24 operating locations
107 network districts

Integrated Management Systems at the DB AG



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The Lord Charles Hotel, Cape Town, South Africa

Paper 9638

Brian Carver
Kevin Moonsamy

Rolling Stock Upgrades to improve safety and combat vandalism

Publisher
[illegible] International Rail Safety Conference

CURRICULUM VITAE

Brian Carver

Brian Carver studied Mechanical Engineering at the University of Cape Town, graduating in 1969. He completed a Masters degree in Business Leadership at UNISA in 1984.

Brian joined the South African Railways in 1969 and was involved in Rolling Stock, Electric Traction and brake systems until he entered the private railway supply industry in 1980.

Brian joined the SARCC in 1991 and was seconded to Metrorail where he is presently serving as Executive Manager (Operations).

CURRICULUM VITAE

Kevin Moonsamy

Kevin Moonsamy studied Electrical Engineering at the University of the Witwatersrand, graduating in 1982. He went on to obtain his Graduate Diploma in Engineering at the same University in 1985.

Kevin worked at RSD (A division of Dorbyl Limited) from 1983 to 1994 gaining experience in diesel-electric and industrial locomotives. He later assumed a key role in the production of the Class 8M EMU project gaining vast experience in coach designs and propulsion systems.

He joined the SARCC in April 1994 as the Manager (Engineering Services) in the Metrorail organisation. He has since been the key figure involved in developing the specifications for the Interior Upgrade of the Class 5M2A commuter coaches and restructuring the Class 9M specifications for new rolling stock.

He is presently acting as the Senior Manager in charge of the Metro Rolling Stock Department.

INTERNATIONAL RAILWAY SAFETY CONFERENCE : SOMERSET WEST

ROLLING STOCK UPGRADES TO IMPROVE SAFETY AND COMBAT VANDALISM

AUTHORS : Brian A Carver Executive Manager (Operations)
: Kevin G Moonsamy Senior Manager (Rolling Stock)

METRORAIL SERVICES

SYNOPSIS

During the years 1991 to 1994 the effects of the turbulent political transitional situation in South Africa spilled over into the Metrorail operating environment, exposing many weaknesses and deficiencies in the rolling stock design. This paper describes both the short term as well as the long term steps that were taken on the existing rolling stock fleet to reduce the risks to the commuter and improve the predictability of the service.

INTRODUCTION

The South African Rail Commuter Corporation owns the assets of the rail commuter service and manages the operating company, Metrorail through agreements with Transnet, Metrorail's holding company.
Metrorail operates in the major urban areas of South Africa. The Rolling Stock component of the assets comprises 4 645 vehicles which, except for the 120 New Generation Vehicles, are of the 5M2 or 5M2A type. These vehicles are used to make up 751 trains which by making [illegible] trips carry over 2 million passengers on a normal working day.
Metrorail controls more than 400 stations, operates on 2200 km of track and has an annual expenditure budget of over R1500m.

The Class 5M2 and the later 5M2A vehicles have been relatively unchanged apart from minor upgrades since their introduction in 1958 up to delivery of the last vehicles in 1985. The oldest vehicles running are 38 years old and consequently the technology is by present standards, outdated. Economic factors make it unlikely that new rolling stock will be acquired in large quantities in the foreseeable future, yet issues such as safety, crime and violence on trains, tight budgetary conditions and issues of patronage dictated that urgent attention be focused on improving the existing stock to reduce the risks that the commuters were being exposed to on a daily basis.

During 1992 whilst a number of modifications and improvements were being investigated, considered and implemented, pre-election violence, vandalism and arson on trains escalated to extreme proportions plunging Metrorail into an environment never before experienced, necessitating a more focused and accelerated programme of improvement. Late in 1992 it was decided to convert two 5M trains comprising 14 coaches, each equipped with various add-on upgrades, in as short a time as possible and place these trains in service in order to evaluate the system under operational conditions. The trains were completed and placed in service in the violence affected areas with a large degree of success and their introduction created some hope in the innocent victims that something was being done.

The political violence subsided after the 1994 elections which removed the immediate crisis although the project proceeded as scheduled through the stages of a major public involvement programme leading to the production of four full prototypes which had been built up from completely stripped down bodies using new vandal, fire and graffiti resistant materials. A national "road show" together with a further public involvement programme was then undertaken using these four coaches to show the commuters and stake holders the progress and ask their opinions regarding the changes. (Refer to fig. 1 for comparison of the changes). The emphasis was now on providing a better and safer service for the commuters.

All the information gathered was then used in the production of a specification and a tender was issued. Recently two contracts were placed, one within the Transnet group and one outside, for 16 coaches each. The first 16 coaches are expected in November 1996 and the balance in 1997 and together with the four prototypes will enable 3 or 4 [illegible] trains to be put in service.
After successful experience with these trains further production runs will follow.


STANDARD METRO PLUS

EXTENT OF TRAIN AND STATION VIOLENCE - 1992/93

During 1992 and 1993 violence in South Africa reached crucial proportions. During this year an average of 68 incidents per month occurred on Metro property mainly in the Soweto area and on the East Rand near Johannesburg. This constituted about 10% of all incidents countrywide.

These incidents resulted in a loss of 21 deaths and 56 injuries on average per month. As a result of this unfortunate situation, ridership suffered substantially resulting in a drop in annual revenue of approximately 15%. The risk to lives and its effect on the Metrorail business was considerable.

An attempt was made to reduce this risk by more effective manpower deployment and upgrade programmes to stations and rolling stock.

ROLLING STOCK PROBLEMS

Problem areas that emerged during this period are listed below:

Windows
Side doors
End doors and cross over between coaches
Lighting, or lack of it
Lack of communication
General vulnerability of the interior (seats, floors, panels and ceilings)
Inability of identifying perpetrators of violence and crime

PROBLEM AREAS AND THE ACTION TAKEN

WINDOWS

Existing windows are of the full drop type having armourplate glass panes and aluminium frames. Problems experienced are breakages due to stonings, theft of aluminium for sale as scrap, ingress of water resulting in rust and a large aperture allowing passengers to be pushed out by perpetrators of violence during the unfortunate period.

The new windows are of the "hopper" type having the lower half fixed, preventing ingress of water and the top half hinging inwards to an angle of 30 deg. The panes are made of 5mm thick vandal resistant polycarbonate sheet which cannot be broken by rocks or bricks and the frames are made of a combination of steel and aluminium, powder coated to render the material of low scrap value. The windows are extremely robust and have been subjected to stringent tests by the Bureau of Standards to confirm their suitability.

The fitting of these windows was extremely effective as reflected by the fact that during the winter of 1994 about half the fleet running through Johannesburg had no windows through breakages, 100% were intact in the winter of 1996 the risk to safety in this area has been adequately addressed.

IMPROVED COMMUTER SIDE DOOR OPERATION

Existing commuter pocket sliding side doors have a simple pneumatic power close operation and are manually opened when the air is released by the door "open" command. The doors are controlled by the guard at the rear of the train.

These doors are easily interfered with and can be prevented from closing by blocking with a foot or even forced open after being closed under pressure. This led to unfortunate incidents where perpetrators of violence threw people from trains and still today, irresponsible persons travel hanging out of the doors. The problem with the doors has been addressed in two phases, the first phase being the replacement of the old door engines and suspension with new, in order to rid the system of old equipment that could not be repaired, while retaining the pocket slider configuration. The second phase, which has just commenced together with the upgrade program, is to place the doors on the outside of the coach with the mechanism and engine outside under a canopy. This configuration places the mechanism out of reach of enquiring fingers and the position of the door makes it impossible for people to ride outside when the door is closed.

The system incorporates local, audible alarms to warn passengers of the door mode, giving a warning tone before the door closes, and an emergency siren when the door is obstructed. A soft stop and re-close is incorporated to cater for door obstructions and a high force is present after the door finally closes. After closing, the door can only be released by train staff or a failsafe condition. In the case of an emergency in the coach, an emergency release is available to the commuters. Once the new outside sliders are fitted, the present safety risks will have been addressed.

END DOORS AND VESTIBULES

The ends of the coaches were originally equipped with 450mm wide doorways, cast aluminium doors and loose, [illegible] railings between the coaches. This configuration was for the sole use of train staff for ticket collection purposes. Theft and vandalism resulted in unsafe conditions and perpetrators of violence now pushed victims out between the coaches.

A programme was instituted to increase the door opening to 650mm, fit a pressed steel door secured with a piano type hinge and enclose the space between the coaches with a "Crystal Wheel" type vestibule. The end doors are also fitted with a fixed polycarbonate window for security reasons. This arrangement allows easy and safe access between coaches for passengers, train staff and security officials.

This arrangement has proved extremely popular with commuters who can now walk down the length of the train safely, at will and it has effectively addressed the risks in that area.

IMPROVED LIGHTING

Standard class coaches are fitted with centrally located, ceiling mounted incandescent lighting which gives an inferior light intensity inside the coach resulting in an atmosphere conducive to crime. The upgraded coaches will have high intensity fluorescent lighting which creates a bright, safe environment and has the advantage of lower power consumption. In addition, lights at each doorway are connected to an emergency battery supply retrofitted to existing trains which provides emergency lighting in the event of a power failure. It is well known that the risk of crime decreases in a well lighted area.

INTEGRATED COMMUNICATION SYSTEM

Driver communication with traffic control was by means of trackside telephones but the hostile environment dictated a safer and more reliable means of on-board communication. Apart from the fact that the cables and telephones were susceptible to theft, the driver was at risk in certain areas if he emerged from his cab to contact operating control.

After investigation it was decided to install trunked train radio systems. These systems are ideally suited for integration with the security network and with future train communications as well. The risk to the driver was reduced and a more cost-effective communication service was obtained.

A trunked radio system has considerable advantages over conventional radio systems due to the fact that it shares the traffic between all the available channels enabling more subscribers to be served per channel. Data can also be transmitted between subscribers at a rate of 1 200 bit/s and calls can be made to the public switched telephone network.

A great need was seen to equip trains with on board public address systems to communicate with commuters in emergencies and to communicate delays and messages, although the nature and vulnerability of this equipment dictates that it must be a "built in" rather than an "add on" feature. This will be a feature in the fully upgraded trains due for delivery later this year.

The on-board public address system, when fitted, is linked to the radio system enabling train staff to use the facilities for making announcements on the train. Transmitting messages from Train Control or the emergency control centre to each coach via ceiling mounted loudspeakers will also be possible. The trains will be equipped with an FM radio receiver, integral with the public address amplifier, allowing radio stations to be played on the train to create a friendlier environment. Other music sources or automatic train announcement means are included in the design of the public address system.

Features to suit "Preacher Coaches" have also been included in the design. A Preacher Coach is a coach that allows religious preachers to preach while the music is muted. Should an announcement be made over the public address system, this muting feature will be automatically over-ridden.

A communication link with the commuters enables them to be kept informed and reduces the risk of them disembarking while the train is standing at the station

INTERIORS

The interior of the coaches presently in use is vandal prone and not graffiti nor fire resistant. Vandalism and arson attacks occur up to the present day for various reasons increasing the risk of death or injury to the commuters and reducing the reliability and predictability of the service.

The upgraded coaches incorporate major improvements to the interior of the vehicles with all materials being fire, vandal and graffiti resistant and environmentally friendly.

In particular the following items received attention:

- replacement of softwood ply floors with rot and fire resistant hardwood ply
- replacement of seating with ergonomically designed and vandal resistant seats
- replacement of hardboard side and ceiling panelling with fire and vandal resistant mouldings.
- improvement to lighting distribution and intensity
- introduction of forced ventilation
- selection of colours and aesthetic designs conforming to corporate identity requirements.
- facilities for physically disabled. Provision has been made for wheelchair-bound persons in one appropriately marked coach per trainset. Space has been created by the removal of some seats to accommodate the wheelchairs where they can be suitably anchored.

The cost effectiveness of these improvements was evaluated over their projected life cycle compared to existing repair costs and cost of replacement of present materials. The evaluations confirm the intervention of [illegible] considerably reduces the risk of loss to commuters and renders the assets more durable, leading to a more predictable service.

TRAIN MOUNTED CCTV SYSTEM

The sudden violence on trains in the Johannesburg/Soweto area indicated an urgent need for an on board surveillance and recording system in an attempt to identify the perpetrators. Although station security surveillance systems were in an advanced state of development at that time, systems on board trains were in their infancy and none were commercially available. Two systems were developed locally and fitted to the two 5M type trains creating much interest and hopefully saving some lives in the process.
The cameras were mounted in vandal resistant steel boxes with dark tinted polycarbonate screens as easily discernable monitors backed up by pinhole cameras concealed in [illegible] any purposeful attempt to mask the cameras by criminal elements. The pictures obtained were monitored continuously in the

train.

Although the systems operated satisfactorily for a considerable time no perpetrators were identified, probably being discouraged by the presence of the visible cameras. The reduction in violence after the elections in 1994 led to a shift in emphasis in favour of fitting station surveillance systems.

PUBLIC INVOLVEMENT

The features discussed in safety, security and all areas that the commuter interacts with are matters that are discussed directly with the commuter in the public involvement programmes which will be ongoing until full implementation is accomplished.

CONCLUSION

After the unfortunate events in 1992 and 1993, the actions that followed up to the present day have all been aimed at providing a better product for the commuter. First and foremost, the aspects of passenger safety in rolling stock has received the highest priority and as can be seen from the text, some of these areas have been rectified rapidly and others require major structural changes which are taking much longer.
In addition to improved safety, the risk to the assets will be reduced due to them being more resistant to arson and vandalism, they will need less maintenance, experience less down time, have longer repair cycles and be more acceptable to commuters both by their appearance and also by the predictability of the service offered. There is much still to be done on the Metrorail rolling stock, but if the improvements described above can contribute to reducing the unacceptably high rate of fatalities and injuries still occurring today, all of the efforts so far will have been worthwhile. Only a combined effort between Rolling Stock, Infrastructure and all Metrorail staff can hope to effectively address the problem of risk to the people we carry on our trains.

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7 October - 9 October 1996
The Lord Charles Hotel, Cape Town, South Africa

Paper 9639

Leung Kai Wing
Li Yun Tai

Platform Gap on Kowloon-Canton Railway

Publisher
[illegible] International Rail Safety Conference

CURRICULUM VITAE

Leung Kai Wing

Mr K. W. Leung started his career in railway operation in 1977 by joining the Mass Transit Railway as a Section Manager Trainee.

In his 10 years with the Mass Transit Railway, he served as Senior Instructor, Area Manager and Safety Officer respectively, and was responsible for the training of operating staff, including Controllers, Supervisors, Operators etc., management of stations and operational safety of the railway.

In 1987 he joined the Kowloon Canton railway as the Line Safety Manager responsible to enhance the operational safety of the railway. Mr. Leung is now the Quality, Safety and Training Manager. He sets up and maintains the Safety Management System for the East Rail of KCR, ISO quality systems and is responsible for the training and development of all operations staff.

CURRICULUM VITAE

Li Yun Tai

Li Yun Tai has been head of the Operations Department in the Kowloon Canton Railway Corporation for 8 years, with experience working in both the Light Rail and East Rail Divisions.

He studied Sociology and Economics in the Chinese University of Hong Kong and has obtained 2 degrees, namely, Bachelor of Social Science, and Master of Philosophy.

He joined the Mass Transit Railway in 1978 and left in 1984 for KCRC. He is now responsible for providing quality customer services in the domestic and cross-border markets of the East Rail Businesses. He is in charge of station and train operations, railway safety, training and marketing. He is a fellow of the Permanent Way Institution and a member of the Chartered Institute of Transport in Hong Kong.

Platform Gap

On

Kowloon-Canton Railway

by

Mr. Y.T. Li
Head of Operations
East Rail Division
Kowloon-Canton Railway Corporation

and

Mr. K.W. Leung
Quality, Safety & Training Manager
East Rail Division
Kowloon-Canton Railway Corporation

1. The Kowloon- Canton Railway

The Kowloon- Canton Railway was initially built in 1910. It was double tracked and electrified in 1983. Now it has 13 stations from Kowloon Station in the south to Lo Wu station in the north over a stretch of 34 Km of tracks for both north and south bound traffic. Out of the 13 stations the Racecourse Station is open only on horse racing days (twice a week).

KCR is a mixed traffic railway. We run 20 trains per hour during the peak hours. We carry on average 660,000 passengers per day by EMU trains. Every day we also run 10 diesel locomotive hauled through trains which run between Hong Kong and Mainland China and 27 diesel locomotive hauled fright trains.

2. Platform Gap

Hong Kong is a hilly place, and KCR stretches along the eastern side of a mountain range. Because of the geographical constraints some station platforms are on the curves. The curvature creates gaps between train body and platform edge. The size of gap is worsen for the EMU trains by the fact that the structure and load gauges take the dimensions of stocks of the mainland China freight wagon which is bigger. The width of the gap between an EMU car door sill and platform edge varies from 112 cm along a straight platform to 309 mm in the worst case at University station on curved platform. With a gap of 309 mm a fat guy can get through easily.

3. Accidents on KCR

In Hong Kong we have to report accidents to the Government in accordance with a schedule. We call these accidents "Reportable Events". Accidents involving the platform gap is a reportable event.

4. KCR Patronage between 1991-1995

The number of passengers travelling by the railway has been increasing ever since the electrification of the railway. The number of Passengers increased from 187.8 m in 1991, to 197.2m in 1992, 205.9 m in 1993, 219.1m in 1994 and 230.6m in 1995.

If nothing is done to address any risk, the number of reportable events would increase as more passengers are crowded at platforms, escalator areas etc which will raise the level of risk

5. Number of Accidents involving the Platform Gap

Between 1991 and 1995 there were all together 237 accidents involving the Platform Gap. All these cases involved the gap between the platform edge and the car door sill, and no case involved the gap between car ends. Among these cases 27 cases involved people sustaining nil injury, 194 minor injury, 16 serious injury and no fatality was reported.

6. Identification of Risk

In the period between 1991 - 1995 there were all together 682 accidents involving passengers/public. Among these 237 cases involved the platform gap, 34.8% of the total.

From studies throughout the years the risk has become obvious and the attributes are identified as follows:

- Instance of slippery surface at the edge of platform causing people to slip and fall inadvertently into the gap.
- People rushing to train especially when train doors are closing and people want to catch the train. In Hong Kong people may rush for seconds and they do not want to miss a train although they know very well that another train will come in about 3 minutes time.
- Peoples general nonawareness of the hazard with the gap and they do not pay attention to it.
- Too many people trying to get off or board. Their sighting of the gap is blocked by others and some people tend to push others for a quicker passage or more rooms
- The width of the gap. The gap can be as wide as 300 mm and they exist at Mong Kok and University stations.

7. Measures to Tackle the Risk

Since the risk has been identified we have done a number of things.

- **Slippery Surface**
  The platform coping was made of non slippery substance already. We installed 3 metal toes stopper strips along the edge of platforms, between the strips a layer of carborundum was painted.

- **People Rushing**
  In 1991 we installed door closing chimes on all EMU trains. The chime would sound before doors started to close. We could not observe any improvement. Therefore in 1993 we conducted a trial of installing the door closing chime at the platform of Tai Wai station. Initially people did not react to the chime. As time went by we observed that people became aware of the chime.
  When the chime sounded a lot of people stopped rushing to the train. Door closing chime was installed throughout the whole system on all platforms in 1994.

- **Peoples Awareness of the Gap**

  In order to catch the attention of the travelling population to the existence of the gap and its associated risk we :

- *painted white the edge of all platforms*
- *put a red reflective fluorescent tape on the underside of the EMU car door sill*
  installed underplatform lighting at curve platforms
- *installed blue neon lights along the edge of curved platforms which illuminate when a train is approaching*
- *posted warning posters and signs at curved platforms to warn people of the gap*
- *posted black spot notices at spots with the greatest number of accidents*
- *made public announcements to advise people to mind the gap*
- *put up new messages on EMU train doors to warn people to mind the gap*

- **Too Many People**

There is no cheap and easy way out. Combined with other justifications to ease the congestion at platforms we have constructed new concourses, two at Kowloon Tong Station , one at Tai Wo Station, one at Tai Wai Station and some more to be built at other stations. These helped to spread the passengers more evenly along the 300 metre long platforms.

- Part time platform assistants are employed to assist and maintain order at platforms during peak hours at the busy stations.
- Education Campaign is launched every year to educate people to be courteous. Risk with the platform gap is always included in the main theme of the campaign.
- Yellow queuing boxes are painted on platforms for people to queue when awaiting trains.

8. How Much We Have Achieved?

- The number of passengers we carried each year continues to rise. The trend is quite constant while the risk level with the platform gap has shown only small improvements.

Year	1991	1992	1993	1994	1995
Passenger Transits (million)	375.6	394.4	411.8	438.2	463.7
Rate Of Increase	0	5%	4.4%	6.4%	5.2%
Platform Gap	40	50	45	57	40
Accidents	0.106	0.127	0.109	0.130	0.087
Risk Level (per million Transits)	0	19.8%	-14.2%	19.3%	-33.2%

- Risk Level at 3 Stations with the Greatest Number of Platform Gap Accidents

Mong Kok Station

Years	1991	1992	1993	1994	1995
No. of Transits (million)	30.8	31	31.4	32.2	33.2
Rate of Increase	0	0.6%	1.3%	2.5%	3.1%
No. of P. Gap Accidents	14	14	11	10	8
Risk Level (per million transits)	0.454	0.451	0.350	0.310	0.241
Change in Risk level	0	0	21%	-4%	-20%

Kowloon Tong Station

Years	1991	1992	1993	1994	1995
No. of Transits	65.4m	66m	68.8m	72.6m	75.8m
Rate of Increase	0	0.9%	4.2%	5.5%	4.4%
No. of P. Gap Accidents	8	13	16	19	7
Risk Level (per million transits)	0.122	0.197	0.233	0.262	0.092
Change in Risk Level	0	62.5%	29%	18.5%	63%

Patronage continues to rise and so is the risk level with the platform gap until 1994. The installation of neon lights, door closing chimes at platforms of this station and red reflective tape on the underside of all EMU's car door sills were completed in mid and late 1994 and hence the improvement is obvious.

<u>University Station</u>

Year	1991	1992	1993	1994	1995
No. of Transits	4.2m	4.8m	7.4m	10.8m	13.2m
Rate of Increase	0	14.3%	54.2%	45.9%	22.2%
No. of P. Gap Accidents	0	5	4	8	5
Risk Level (per million Transits)	0	1.042	0.541	0.741	0.379
Change in Risk Level	0	N/A	-48.1%	37%	-48.9%

This station has the smallest radius curve and thus the biggest gap of 309 mm

This station was used mainly by University students before. Four years ago a bus terminal was constructed outside. Since then passengers include aged people and young children.

The patronage continues to rise. The risk with the gap increased for a couple of years, but now apparently is under control.

The Next Step

Recently we have conducted a trail at the up line platform of Tai Po Market station. We have installed a rubber filler at every EMU car door position along the edge of the platform.

Since the installation in July 1996 until end August there has not been any accident involving the gap of this platform.

Dependent on the result of trial of the rubber gap filler we may install the fillers along all straight platforms. The estimate cost is about HK $ 13.5 million.

We are also exploring the feasibility of installing a gap closer system which closes the gap for passengers boarding and alighting. Upon completion of platform duties the gap closer will retreat for the train to depart. However there are technical problems and the costs of this system may be so high making it financially not viable.

Conclusion

With all our efforts, we have some achievements, but we have not been able to minimise the number of accidents involving the Platform Gap. Facilities which are designed to reduce passenger accidents tend to be expensive and even difficult to be installed on an operating railway. We are still searching for practical and less expensive solutions to the problem in order to raise the safety standard of the railway.

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Paper 9640

Jean-Bernard Benech

Safe carriage of hazardous materials

CURRICULUM VITAE

Jean Bernard Benech

Jean Bernard Benech is an Aeronautical Engineer who was employed by SNCF in 1968

1968 - 1980 (12 yrs)
He has been in charge of several local depots with electric and diesel engines. His job was to manage drivers, engines and rolling stock maintenance.

1980 – 1994 (14 yrs)
He has been a regional manager in charge of railway traffic operations (there are 23 regions on SNCFs network). Jean Bernard was in the Toulouse area, south of France, along the Pyrenees mountains, near Spain.

1994 –
Since 1994 he has been head of the SNCFs Safety Studies Centre, which is part of SNCFs Headquarters. His office is now in Paris where he maintains a global view of railway Safety problems with a systematic approach.

SNCF
Délégation Générale à la Sécurité

by

Jean-Bernard Benech
Head of the SNCF's
Centre for Safety Studies (CES)

and

Jean-Georges Heintz
Dangerous Goods Expert

SAFE CARRIAGE OF HAZARDOUS MATERIAL

Each year, railway companies transport several ten million tons of hazardous goods. The railway mode is safe and well suited to the large scale transport of hazardous goods. The transport of hazardous substances on SNCF accounts for 15% of freight shipments per year. This activity poses risks to the environment and has a major impact on the company's image. Therefore, SNCF has developed for many years, a continuous policy to enhance the quality and safety of these shipments combining the overall risk assessment and a specific approach to important operating site.

A. Background

1. Traffic Figures

2. Incidents and accidents involving hazardous materials

3. Safety system

B. New Developments since 1990

1. 1990 - Introduction of the first plans for hazardous material
2. 1992 - Setting the safety committee for hazardous materials
3. July 1993 - Creation of "*Présence Fret*"
4. 1993 - 1994 - Overall safety assessment of the carriage of hazardous material
5. 1994 - 1998 - Safety assessment of specific sites

A. Background

1. Traffic figures

- 15 per cent of the freight business
- 6 billion tonne-kilometres
- 350,000 loadings
- 25 per cent of the market
- 1/3 in wagon-load and 2/3 in train load traffic
- intermodal transport (10 per cent of turnover)

RID Class	Goods	tonnage (10^3) '94 figures	tonnage (%)	wagon-nos.
1	explosive substances and articles	15	0.08%	750
2	gases: compressed, liquefied or dissolved under pressure	3,867	21.90%	79,000
3	flammable liquids	8,921	50.30%	150,647
4.1	flammable solids	1,173	6.50%	21,059
4.2	substances liable to spontaneous combustion			
4.3	substances which, in contact with water emit flammable gases			
5.1	oxidising substances	1,134	6.40%	25,200
5.2	organic peroxides			
6.1	toxic substances	285	1.50%	5,952
6.2	infectious substances	[illegible]	1.70%	22,053
7	radioactive material	81	0.45%	1,111
8	corrosive substances	1,652	9.40%	29,452
9	miscellaneous dangerous substances and articles	254	1.40%	[illegible]
		17,672	100%	340,460

- Railway network: 30,000 kilometres
- Fleet consisting of 19,000 wagons (95% privately owned)
- Tank-wagons account for one third of the wagon fleet
- marshalling yards
- main freight yards

2. Incidents and accidents involving hazardous materials

Some 120 events are reported every year in connection with the carriage of dangerous goods. 110 of them (leakage, dripping, smells) are attributed to minor rolling stock failures or to the difficulties associated with the closing of equipment.

The remaining 10 are treated as "accidents", knowing that a derailment is treated as an accident, even if the dangerous material is not involved (no loss of containment). Of the remaining 10, 2 give rise to a loss of containment and the resulting damage can be quite significant.

3. Safety System

In terms of safety, trains conveying dangerous goods are subject to the same preventative measures, as any other category of trains.

Rules and regulations applicable to the carriage of dangerous goods.

Over and above the safety rules and procedures enforced for all train movements, the carriage of dangerous goods is subject to specific regulatory rules and safety measures so as to:

- *make possible the carriage of goods representing some 3,500 substances classification numbers and 90 hazard identification numbers*
- *Ensure maximum safety with this objective in mind.*

SNCF apply the contents of the International Regulation for the carriage of dangerous goods (RID). Apart from a few features which are country-specific, it is the only set of rules to be applied in the European Union as a whole.

This set of rules covers the following items:

- packaging and tanks
- wagons & associated equipment
- labelling and marking
- transport related documents
- the classification of goods according to hazards

- incompatibilities between various dangerous goods (need to separate wagons carrying some explosive materials from other wagons

Other prevention techniques

The reliability of wagons is very much dependant on maintenance practice. SNCF draws up such rules for the wagon-underframe in terms of frequency and contents, the wagon-owner being responsible for the maintenance of its superstructure. The French Association of Private Wagon Owners (AFWP) publishes a guide-book for supervisors and maintenance purposes. Appendix IX of the RID applies to the checks to be performed on tank wagons by official experts.

Before the goods are accepted for carriage, the regime provides for checks by SNCF staff to ensure that the wagon is fit for such haulage. They carry out such checks on empty or loaded wagons due to leave a rail-connected location or already in transit, at designated sites.

SNCF is party to the "Accord en confiance/Trust Regime" applicable to the transfer of dangerous goods between the railway companies involved in an international freight-movement; this agreement has been in force since 1 January 1991 and is also applied by SNCF on domestic routes. Destination-railways ensure, through random checks, that this agreement is properly enforced. This procedure involves ten checks, four of which are required on the consignment-related documentation and six on the wagon.

In terms of supervisory and monitoring of wagons en-route, supplemented by the overall control of train working, technical examinations are carried out by rolling stock technicians.

NAW Information System

Information as to the actual consignments of dangerous goods is provided in real-time by marking on the wagon itself (substance identification and hazard identification numbers) and/or on the supporting documents.

The new wagon-routing information/NAW system applied by SNCF supplements RID rules and regulations, covers all freight consignments and enables computerised tracking of the relevant information for a HM wagon during transit, thereby giving its actual position in the train-consist or in a marshalling-yard

B. New developments since 1990

These developments have to be seen against the background of increasing pressure from elected members or department officials who are concerned with the risks from the transport of dangerous goods. SNCF had to develop the most appropriated response as a result of increasing regulatory constraints extending beyond transport situations and geared to the prevention of potential damage for the environment - whether built up or not. All safety-related initiatives are not set out in detail, nor measures such as the appointment, by SNCF, of regional advisors for dangerous goods or the implementation of QA measures in yards entrusted with the forwarding of dangerous goods.

I - 1990: Introduction of the first plans for hazardous materials

Marshalling-yards are considered by Environment Department officials in particular, as critical locations where wagon numbers and therefore dangers tend to concentrate. As of the beginning of the 1990's, SNCF have taken a specific approach to safety in conjunction with the Home office (public safety) and have implemented plans for hazardous materials in order to increase the efficiency of emergency services in the event of accidents. At a later stage, some prefectoral services asked for a risk analysis to be conducted in three marshalling yards.

II - 1992: Setting the safety committee for hazardous materials

Following a rather serious accident (fire - pollution) that occurred in Aix-les-Bains on 16 March 1992, an enquiry was commissioned by the Department of Transport (Duguet Report). The overall background and the contents of that report led to a decision, by SNCF's Chief executive, to further improve the transport of dangerous goods, from a safety point of view. A safety committee - chaired by the Operations Director and involving other functions - was set up in order to identify strategies to improve the safety system. This committee is currently chaired by the Director in charge of safety, Head of the General Safety Directorate. The Centre for Safety Studies is responsible for secretarial work.

In addition to the response required following the technical recommendations given in the Duguet report, the Committee has focused on the need to properly identify the substance being carried and to set up a special control body responsible for hazardous materials. It also set out to undertake an overall risk analysis so as to facilitate the decision-making process in terms of preventative policies. It is no easy task to gain an in-depth knowledge of such hazards since materials are classified according to their substance/hazard codes (2500 and 90 codes respectively). This work was conducted jointly by a company specialising in quantified risk assessment and a body reporting to the Environment Department and specialised in the review of accidents resulting from hazardous substances.

III - July 1993: Creation of "PRÉSENCE FRET"

This body forms part of the Freight Division and has its office in Dijon (Burgundy). It plays a vital role in providing information, on a round-the-clock basis, for the carriage of dangerous goods. The information is derived from the above-mentioned wagon-routing system. Présence Fret staff are involved in the event of incidents or accidents affecting the carriage of hazardous materials, in response to SNCF's regional control centres. Their remit is to advise relevant safety services, located at the shippers, consignors, consignees or wagon-owners premises. Individual forms are drawn up for each event and a monthly report is issued.

IV - 1993 - 1994: Overall safety assessment of the carriage of hazardous materials

The overall safety assessment of the carriage of dangerous goods was launched in 1993 and finalised in 1994 in order to develop strategies for further improvements. This work was the outcome of co-operation and was supported by the Department of Transport, the Home Office (Public Safety) and the Environment Department.

It gives a detailed account and description of the consequences of a hypothetical accident involving a tank-wagon, according to the nature of the substance carried. Various accident scenarios were selected by the Environment department and examined on the basis of the substances carried, the main hazards being: fire, explosions, UVCE - unconfined vapour cloud explosion-, BLEVE - boiling liquid expanding vapour explosion-, toxic release, soil and/or water pollution.

This assessment was finalised in 1994 and led to some preventative steps being taken for the overall network and other measures applied to specific sites.

With regard to the overall network, the decision was taken to increase the number of hot-box detectors installed, to improve the maintenance -

standards on some routes and the efficiency of wagon-use. With regard to case-studies on sites and risks associated with wagons shunting movements and the concentration of wagon-numbers within the same site, this work highlighted the possible improvements to be made on the basis of local circumstances - in order to reduce the actual risks incurred.

Further effort was directed towards the prevention of local risks and this initiative was in line with the issues of concern, at ministerial level, mentioned above. SNCF thus developed its strategy for safety review geared to specific sites, taking a pragmatic approach to risk analysis methodology, up-dated prevention plans if required and enhanced plans for the carriage of dangerous goods which had been implemented in marshalling yards since 1990.

V - 1994 - 1998: Safety Assessment focused on specific sites.

Some forty sites are concerned, including 20 marshalling yards. Work is carried out by local or regional SNCF services with the support of the General Safety Directorate Infrastructure Department. The relevant local services are involved in such analyses so as to ensure that local circumstances are fully addressed. As an added benefit, this strengthens the dissemination of the safety-culture locally.

DGS has developed methodological guidelines for such work so as to harmonise the approaches taken and to facilitate work-progress. They are based upon the contents of the overall safety review (1994) and upon a pragmatic and iterative process leading to the contemporaneous execution of several experimental studies so as to check the feasibility of investigations to be made.

The local review-network is conducted in liaison with Government services. It is aimed at meeting public safety requirements (prevention of technology related hazards and implementation of emergency plans). It should focus of the safety features involved in the carriage of dangerous goods for a given railway site and facilitate liaisons with the various partners concerned, notably outside the railway - not an easy task given that many people are not conversant with railway operating issues.

Most aspects covered are the same as in the hazard studies conducted in France in accordance with the Environmental Protection Act (1976). Government officials are quite familiar with their format although the contents are more focused on railway operations, notably in connection with wagon-sorting and associated risks.

CONTENTS OF SAFETY-ASSESSMENT FOCUSED ON SPECIFIC SITES

Introduction

- SNCF and the carriage of hazardous materials
- Company's environmental policy
- Remit and scope of work
- Restrictions for confidential data and for the prevention of criminal damage
- Presentation of site: name, historical background, role in the local economy……

Environment surrounding the site

- (Non) built-up environment
- The environment is seen as a potential source and a target likely to be affected by an accident resulting from the carriage of dangerous goods
- Geographical, meteorological and geological data
- Access to site
- Transport routes, public places, public and private utilities networks in the vicinity of the railway

Description of the facilities and activities carried out

- The operations involving wagons carrying dangerous goods are described from the time of arrival at the site until the time of departure from the site
- Facilities have to be properly described in order to subsequently demonstrate the level of safety and risk-prevention attained
- A thorough review of the carriage of dangerous goods is helpful to check that the hazards to be analyses were properly selected, to pinpoint undesired events and define the resources needed in the event of and incident/accident.

Overall safety system

This consists of three sections describing the existing preventative measures and possible safety-enhancements, in particular, as defined in the overall safety assessment (1994).

The first section deals with railway safety in general
The second section covers more specific measures in relation to the carriage of dangerous goods, bearing in mind that overall safety-measures are beneficial in this respect also
The third section explains how the company is organised to manage safety issues, locally

Identification of undesired events

On the basis of information regarding the carriage of dangerous goods on the site (characteristic of the substance, number of empty/loaded wagons, nature of hazard...), undesired events are identified and investigated (fire, explosion, pollution, toxic release, BLEVE, UVCE...) with a determinist (and maximalist) approach so as to evaluate their potential effects on the environment, notably with an emphasis on their range.

Risk assessment and preventative measures

The beginning of this section deals with the collection and analysis of causes likely to give rise to undesired events. This is based on the analysis of hazardous materials events and meaningful events reported during the five previous years. The events are associated with all freight wagons (the carriage of dangerous goods accounts for 5% to 12% of total traffic figures depending on marshalling yards) because the number of incidents/accidents involving dangerous goods only is too low for such an approach to be valid. Hazards are examined according to sets of sidings and analysed according to the nature of causes and severity of consequences (damage-rates on wagons). Knock-on effects are examined with regard to actual wagon positioning. Further action to reduce wagon - damage is planned or tested if necessary

Action taken after and event involving dangerous goods

This section deals with the conditions for an intervention as a result of the event, follows on from the preceding sections and primarily aims at strengthening the arrangements whereby emergency services are called in, the section may also define resources needed in the event of an incident/accident.

Conclusion

Each year, railway companies transport several ten million tons of hazardous goods. The railway mode is safe and well-suited to the large scale transport of hazardous substances. However this activity poses risks to the environment and has a major impact on the company's image.

So we must continue to demonstrate to State Authorities and the general public that the railway is efficiently organised and safe. The purpose of SNCF's long-standing policy is to ensure that the level of quality and safety is properly maintained.

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A. W. Smith

The Spoornet SPAD Investigations

CURRICULUM VITAE

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A PRESENTATION FOR THE INTERNATIONAL RAILWAY SAFETY CONFERENCE, 1996

THE SPOORNET SPAD INVESTIGATION

BY: A.W. SMITH, SPOORNET, CAPE TOWN

SYNOPSIS

SPOORNET RECENTLY CONCLUDED AN INVESTIGATION TO EXPLORE MODERN DEVELOPMENTS IN THE FIELD OF RAILWAY SAFETY AND HEALTH. SPECIAL EMPHASIS WAS PLACED ON UPDATING OUR UNDERSTANDING OF THE CIRCUMSTANCES SURROUNDING SPAD TYPE INCIDENTS.

IN ESSENCE, THE INVESTIGATION TESTED SPECIFIC FINDINGS FROM A LITERATURE SURVEY ON RAILWAY RELATED SAFETY AND HEALTH ISSUES, AGAINST THE PERCEPTIONS OF SPOORNET TRAIN DRIVERS OF THEIR PRIVATE AND OPERATIONAL CIRCUMSTANCES. THEIR PERCEPTIONS WERE DETERMINED THROUGH A QUESTIONNAIRE STUDY.

THIS PRESENTATION BRIEFLY HIGHLIGHTS THE QUESTIONNAIRE STUDY AND CONCLUDES WITH AN APPRAISAL OF SOME OF THE FINDINGS AND RECOMMENDATIONS.

INTRODUCTION

The need for Spoornet to conduct a study into the basic causes of SPADs arose as a result of a mutual understanding between Management and Labour, that a stage had been reached where the role of the driver in SPADs and related incidents, needed proper clarification in the light of recently acquired information on chronobiology.

The SPAD acronym perhaps masked the true character of the investigation. At the outset it was agreed that SPADs were but the symptom of a very complex set of problems and conditions. The SPAD Brief was accordingly formulated to address the issue at its source.

OVERHEAD NO. 1 : THE SPAD BRIEF

The issue is not so much that a driver passed a signal at danger without authority, but rather that his vigilance was probably compromised during a period when critical judgement was required. There is seemingly a constellation of reasons for this state of affairs, not least of which was an apparent lack of appreciation of the modern definition of the word "Health".

OVERHEAD NO. 2 : THE DEFINITION OF HEALTH

Recent legislation in the form of the Occupational Health and safety Act (Act 85 of 1993) emphasises the inextricable link between health and safety. Legislation now makes it clear that the objectives of accident prevention are humane as well as economic.

OVERHEAD NO. 3 : THE INEXTRICABLE LINK BETWEEN SAFETY AND HEALTH

The new impetus for safety and health steered the SPAD investigation along a course that necessarily indicated a multi-discipline, multi-dimension approach.

The SPAD Team was organised into 3 specialist sub-groups with each sub-group focussing on one of the three identified dimensions of the SPAD problem, i.e. the Technical dimension, the Human Factors dimension, and the Management dimension. Separate reports were prepared by the SPAD sub-groups on each of these three dimensions. These separate reports, together with an independent Questionnaire Report, were combined to form the body of one cohesive SPAD report.

The SPAD investigation was essentially limited to a general survey of the relevant literature with a view to extracting what is appropriate from a railway point of view. The independent Questionnaire Study was included to gauge the drivers own perceptions of the problem, and to test for correlation with the literature.

1.1 Technical Report Summary

Where possible the technical evaluations included quantification of Spoornet Safety performance data, SPAD incidents, evaluations of the driver's technical role, and the perceptions of the broader problems as seen by the drivers themselves

With reference to Spoornet's SPAD statistics, it is demonstrated that a "SPAD - Iceberg effect" is present and that the published SPAD Statistics understate the true SPAD situation.

The merits of investing in Hi-Tech communications and data systems is discussed - particularly with reference to on-board Data recorders (Black Box)

The overall sentiments expressed in the Technical Report are that a "Quantum Shift" to Hi-Tech Operations is probably not advisable at this stage and that more can possibly be gained in the shorter / medium term, by following an "Accelerated Incremental Approach" towards technological development.

2 Human Factors Report Summary

The Human Factors Report assessed the SPAD problem from the point of view that a better understanding of train drivers as human beings, and how humans function with respect to shift work (biological rhythms), is crucial to the optimisation of the reliability and safety of our Railways. The premise is that if human functioning and behaviour is not properly understood, then an appropriate balance between human factors, technical considerations and productivity will not be achieved.

Gaps in our understanding of human chronobiological functioning were found. The Guaranteed Roster Working agreement governing the drivers shift work is cited as a case in point where gaps in our understanding has resulted in a shift work agreement with little scientific or medical foundation.

It is suggested that Spoornet will need to develop a clear profile of the person wanted on the footplate in future, particularly from a safety and health point of view. It is also suggested that a programme is developed aimed at revolutionising the career prospects of our drivers through a scientifically based process of recruitment, selection, training and monitoring.

Management/Data Report Summary

The attentions of the SPAD - Data Group were centred on assessing the current Spoornet situation with regard to data and management information, specifically in the safety and health domain. It is argued that the accident statistics and information are not useful for proper causal analysis and scientific research purposes. One of the reasons cited is that some of the Regions are following uncoordinated and unstructured procedures when investigating and reporting on accidents and incidents. This uncoordination and lack of uniform structure extends also to the manner in which drivers are managed post SPAD. Serious operational infringements by drivers are also dealt with on a discretionary basis by each Region, and valuable information is lost in this process. The Data Report concludes with practical recommendations to address these problems

1.4 The Driver's Operating Environment/Circumstances

A brief introductory overview of the driver's operating environment and circumstances is offered to fill in some background to this presentation for those who may not be familiar with some of Spoornet's driver/operational details

Spoornet currently manages 5 distinctive railway operations, e.g.:

Heavy Haul; Main Line Passenger;
Commuter Passenger; Fast Goods;
General Goods.

In most cases, these 5 operations take place over common/mutual lines with common signalling systems. Traction is by either AC or DC electric, diesel or dual diesel/electric, or dual AC or DC electric locomotives with dynamic or regenerative braking on most locomotives. Train brake systems are either airbrake or vacuum brake (some vintage steam hauled trains are also operated). It is not unusual for a driver to be qualified in all these modes of traction and braking systems. It is also possible for a driver to operate different types of trains in one shift.

OVERHEAD NO. 4 : DRIVER POPULATION

OVERHEAD NO. 5 : CIVIL ENGINEERING FACTORS

OVERHEAD NO. 6 : TRAIN TYPES

OVERHEAD NO. 7 : SIGNALLING AND OPERATING FACTORS

OVERHEAD NO. 8 : LOCOMOTIVE DETAILS

OVERHEAD NO. 9 : CREW WORKING

1.5 Spoornet's SPAD History

Someone once said that if you torture the statistics long enough, they will eventually confess. An historical statistical interpretation of our SPAD history suggests that for more than a century (1860 - 1960) our drivers have stood up fairly well to (random) shift work and extraordinary long hours on duty doing a job, which by today's standards, could be described as crude, unhealthy and physically exhausting. The situation is different today - technical progress seems to have aggravated the problem. Tolerance to shift work seems to diminish as physical load (heavy, hot atmosphere) diminishes and is replaced with intellectual and mental work load. (J. Carpentier and P. Cazamian).

OVERHEAD NO. 10 : EQUIVALENT 8 HOUR DAYS WORKED PER MONTH PER DRIVER

7 THE QUESTIONNAIRE INVESTIGATION

7.1. Purpose

To comprehensively survey the working and private circumstances of Spoornet train drivers with a view to broadly identifying the extent of the drivers personal perceptions of these conditions and factors that might contribute to SPAD-type incidents

7.2. Rationale

Driver participation in the SPAD investigation was seen to be of major importance. Of equal importance, was the determination of the perceptions of the drivers of their work circumstances from a safety and health point of view. To emphasize the participative nature of the investigation, it was agreed that all Spoornet drivers should be given the opportunity to participate

Anonymity was also considered to be of importance to encourage open and honest participation.

Under the circumstances, it was considered that a questionnaire survey represented the best option

2.3. **Procedure**

One the reasons for employing independent external assistance with the questionnaire study was to provide a neutral and confidential environment external to Spotnet to encourage the drivers to openly and honestly participate in the study where their anonymity would be guaranteed.

Several weeks before launching the questionnaire, a personalized letter was sent to each and every driver explaining the nature of the investigation and the modus operandi that was to follow.

The South African Footplate Staff Association likewise embarked on a communication campaign encouraging their driver members to participate.

The questionnaire, in draft form, was duly tested under carefully controlled conditions on a random sample of 10 drivers. Feedback from this test resulted in several changes to the final questionnaire.

A copy of the final moderated questionnaire together with a personalized covering letter, as well as a pre-addressed, post paid envelope, were all packaged and sealed into one personalized envelope per driver. The approximately 3 000 sealed envelope packages were delivered by hand to every depot throughout the country. The responsibility for final distribution of the questionnaire packages to each driver was delegated to the depot supervisory personnel.

A check list was used by each depot to monitor receipt of the questionnaire package by each driver.

According to this monitoring process, approximately 99% of the total Spoornet driver population received a questionnaire package.

The drivers were allowed a period of about 6 weeks to complete the questionnaire in private and in their own time. Once completed, the questionnaire was sealed in the pre-addressed, post paid envelope and simply dropped by the driver into his nearest post box. The pre-addressed envelopes containing the completed questionnaires were delivered via the national postal system to a private address for independent external analysis. Confidentially was thus guaranteed since Spoornet had no access to any of the completed questionnaires.

2.4. Questionnaire Design

The questionnaire was intended to explore, from a safety and health point of view, as many features as possible of the complex interactive nature of the train driver and his operating and social environments. The risk of "overloading" the questionnaire and making it too long was considered to be worth taking in a preliminary study of this nature. (About 33% of the drivers responded to the questionnaire, which was 30 pages long with 411 questions).

The questionnaire was essentially a composite battery of 13 sub questionnaires tailored, where necessary and according to the findings of an extensive literature search, to suit a railway type operation (irregular shift patterns):

The Standard Shiftwork Index (SSI), developed by the Shiftwork Research Team of the British Medical Research Council constituted the major component of the questionnaire. Also included was a sleep apnea scale which was developed locally for this study.

OVERHEAD NO. 11 : QUESTIONNAIRE COMPOSITION

The internal consistency and dimensionality of the various scales used in the questionnaire, were investigated to determine their suitability for application in the Spoornet situation. The results obtained indicated that the applicability of the scales to a railway operation could be viewed with confidence and that it would also be possible to compare certain of the Spoornet results (random shiftwork) to the results reported by the aforementioned British group (regular shiftwork).

2.5. Findings

Some of the findings of the Questionnaire Study are summarised below

2.5.1. There is a "SPAD – Iceberg Effect". For every SPAD detected or reported, about 3 go unreported.

2.5.2. There also appears to be a "SPAD Paradox Phenomenon". Three "paradoxes" have emerged:- (From the literature)

(a) The longer the hours worked – the less the chances of an unsafe incident.

(b) As technology improves – so fatigue effects worsen.

(From untested Sponsor experience)

(e) The greater the extent of driver multi-skilling - the safer the driver

2.5.3. Drivers who have had SPADs work significantly more hours than drivers who have not had SPADs.

2.5.4. The incidence of certain medical conditions reported by the drivers are significantly higher than found in the general white male population.

OVERHEAD NO. 12 : FREQUENCIES OF TRAIN DRIVERS WHO HAD BEEN TREATED FOR PARTICULAR MEDICAL CONDITIONS

2.5.5. There are a number of noteworthy conditions experienced in the cab.

OVERHEAD NO. 13 : NOTEWORTHY CONDITIONS EXPERIENCED IN THE CAB

2.5.6. About 56% of the drivers would like to stand and drive from time to time.

2.5.7. Rain and misty conditions are considered to be the highest risk conditions for SPADs to occur.

2.5.8. A relatively large number of drivers are at risk of having obstructive sleep apnea.

OVERHEAD NO. 64 : RESULTS FOR THE MOST COMMON SYMPTOMS OF SLEEP APNEA

2.6 <u>Recommendations</u> (Questionnaire Study)

2.6.1. Any driver involved in a SPAD-type incident should immediately undergo a sleep assessment.

2.6.2 All drivers should be assessed annually on their physical health, mental health and work performance. The physical health assessment should include a sleep assessment.

2.6.3. Drivers and their spouses should be educated in ways of coping with shift related problems.

2.6.4. The roster working system should be revised according to the latest proven developments in shift work design.

2.6.5. The selection process of suitable train drivers should include an assessment of the following personality characteristics:

(a) lack of neuroticism.

(b) flexibility of sleeping habits.

(c) ability to overcome drowsiness.

2.6.6. An assessment should be made of the "irregular leg movement phenomenon" to determine whether it is a learned behaviour. This phenomenon has not been described in the literature as far as periodic leg movements during sleep are concerned. In this context, the possible subconscious activation of the vigilance pedal should be further investigated.

2.7. <u>Conclusions</u>

2.7.1. There is no easy or single solution to the SPAD-type problem. It is a multi-dimensional problem involving the technical, human resources, management and socio-medical disciplines. In this context, there is a need to understand that Safety and Health are inextricably linked.

2.7.2 Safety and Health must be placed on an equal footing with the rest of the business.

2.7.3. Safety and Health must be seen in the context of the "6 Absolutes"

OVERHEAD NO. 15 : SAFETY AND HEALTH IN THE CONTEXT OF THE "6 ABSOLUTES"

2.7.4. The Questionnaire Study has shown that drivers recognise a number of shift related problems, ergonomic issues and technical problems and complain of them.

OVERHEAD NO. 16 : DRIVERS PERCEPTION OF THE CAB ENVIRONMENT

Apart from chronic sleep loss, the disruption of work-sleep-rest cycles, time on shift and time of day, the drivers complain of numerous other issues from social interactions through to dietry and medical disorders. These wide-ranging issues are all relevent in generating fatigue and inattentiveness. The question at issue however, was whether or not these wide-ranging factors, either individually, collectively or in any combination, contributed to critical incidents as specified in the SPAO Brief.

It appears that the literature generally does not support the hypothesis that critical incidents occur simply because drivers are fatigued. The suggestion is therefore that the problem of driver inattentiveness at critical moments, needs be addressed by focusing attention on the disturbances to the driver's chronobiological functioning.

In general, the findings of the Questionnaire Study are in accordance with many of the commonly held views in the field.

5. ACKNOWLEDGEMENTS

Many people have assisted with this SPAO project, either directly or indirectly and in many different ways - be it through advice, encouragement, active participation, availability of resources, co-operation, etc. The names of these people are listed below (strictly in alphabetical order) - any omissions are unintentional and sincerely regretted.

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Willie Wapenaar	Assistant Manager (Human Resources)	Johannesburg
John Wiggill	Assistant Manager (Rail Operations)	Johannesburg

In addition to the foregoing, acknowledgement is also due to the work of numerous researchers for their contributions to a better understanding of the Safety and Health issues pertaining to shift work in general and to Railway Operations in particular. This SPAD report has drawn heavily on the findings of these research workers and in this respect a special word of acknowledgement and thanks is due to:

NAME	POSITION	PLACE
Dr. Alison Bentley	Medical Doctor	Johannesburg
Prof. Simon Folkard	Medical Research Council, Sheffield University	UK
Paul Howard	Transport Marketing Inc.	Hudson
Dr. George Kaulin	Rail Simulation and Training Institute	Chicago
Dr. Jan van Zonder	Ergonomics and Human Resources Consultant	Pretoria
Prof. Deléne Visser	Department of Human Resources Management Rand Afrikaans University	Johannesburg

Lastly, but by no means least, a very special word of thanks is due to the SPAD team for their dedication to this project over the past 2 years. The additional work load was willingly and ably carried by each member over and above their normal duties. This often resulted in voluntary and uncompensated additional time over week-ends and after normal hours. Frequent travel and nights away from home were also features of the SPAD team's activities - mainly due to the dispersed location of the members. There can be no doubt that the efforts of the SPAD Team will contribute significantly to the establishment of a platform as the departure point for further operational Safety and Health research and investigation within SPOORNET.

<u>**The SPAD team members are:**</u>

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THE SPAD BRIEF

TO COMPREHENSIVELY INVESTIGATE AND TO REPORT WITH RECOMMENDATIONS, ON THE UNDERLYING CAUSES AND CONTRIBUTORY FACTORS WHICH MAY LEAD TO THE IMPAIRMENT OF TRAIN DRIVER / CREW FUNCTIONING AT CRITICAL MOMENTS DURING THE SHIFT CYCLE.

OVERHEAD NO. 1

THE DEFINITION OF HEALTH

HEALTH MEANS THE

COMPLETE *PHYSICAL,*

MENTAL AND SOCIAL WELL-

BEING OF A PERSON AND

NOT MERELY THE ABSENCE

OF DISEASE.

OVERHEAD NO 2

THE INEXTRICABLE LINK BETWEEN SAFETY AND HEALTH

ONE OF SOUTH AFRICA'S MOST DISTINGUISHED OCCUPATIONAL HEALTH PHYSICIANS, DR KENNETH SWAKAMISA, COMPARED THE INEXTRICABLE LINK BETWEEN HEALTH AND SAFETY TO SIAMESE TWINS.

"MANY SURGICAL PROCEDURES WHICH HAVE TRIED TO SEPARATE SIAMESE TWINS TO GIVE EACH INDEPENDENT LIFE HAVE RESULTED IN THE DEATH OF ONE OR BOTH TWINS"

OVERHEAD NO 5

DRIVER POPULATION

WHITE AFRIKAANS SPEAKING MALES	± 90%
WHITE ENGLISH SPEAKING MALES	± 7%
OTHER POPULATION GROUPS	± 3%
DRIVER POPULATION	± 3 000

HIGHLY UNIONISED

OVERHEAD NO. 4

CIVIL ENGINEERING FACTORS

CAPE GAUGE — 1065 MM

STEEP GRADES — [illegible] AND STEEPER COMMON

SEVERE CURVATURE — 120 M RADIUS COMMON

NUMEROUS TUNNELS — SOME VERY LONG

TRAIN TYPES

HEAVY HAUL (AIRBRAKE)	±20 000 TONS
GENERAL GOODS (VACUUM)	± 2 200 TONS
HIGH SPEED GOODS (AIRBRAKE)	± 50 VEHICLES
MAIN LINE PASSENGER (VACUUM)	± 20 VEHICLES
COMMUTER PASSENGER (VACUUM & AIRBRAKE)	± 12 VEHICLES

TRAINS OFTEN RUN OVER LONG DISTANCES WITH SEVERAL LOCOMOTIVE / CREW CHANGES EN ROUTE.

OVERHEAD NO. 6

SIGNALLING AND OPERATIONS FACTORS

COLOUR LIGHT SIGNALS (CTC)

SEMAPHORE SIGNALS

FIXED SIGNALS (WARNING BOARDS)

RADIO ORDER

WOODEN STAFF

IN MANY CASES, DIFFERENT TYPES AND CATEGORIES OF TRAINS ARE OPERATED OVER SHARED ROUTES

OVERHEAD NO. 7

LOCOMOTIVE DETAILS

ELECTRIC AC (50 kV) (AIRBRAKE)

ELECTRIC AC (25 kV) (AIRBRAKE + VACUUM)

ELECTRIC DC (3 kV) (AIRBRAKE + VACUUM)

DUAL ELECTRIC WITH DIESEL (AIRBRAKE + VACUUM)

DUAL ELECTRIC (AC OR DC) (AIRBRAKE)

DIESEL (AIRBRAKE + VACUUM)

DIESEL (VACUUM)

STEAM (VACUUM)

A NUMBER OF DRIVERS ARE CERTIFICATED TO OPERATE STEAM, DIESEL AND ELECTRIC LOCOMOTIVES WITH VARIOUS BRAKE TYPE COMBINATIONS

OVERHEAD NO. 8

CREW WORKING

- GUARANTEED ROSTER SYSTEM
- CROSS TRIP OR ROUND TRIP WORKING
- NO "BOOK-OFFS" AWAY FROM HOME
- SHIFTS UP TO 14 HOURS
- TIME OFF BETWEEN SHIFTS; 8 TO 12 HOURS
- TWO-MAN TRAINS

OVERHEAD NO. 9

EQUIVALENT 8 HOUR DAYS WORKED PER MONTH PER DRIVER

DEPOT	*DECADE 1926-1936*	*DECADE 1951-1961*	*DECADE 1981-1991*
De Aar	49	54	29
Bloemfontein	53	56	31
Kroonstad	49	55	30
Braamfontein	55	58	34
Germiston	57	59	31
Pretoria	51	56	33
Country Average	48	51	29
Average Train kms / year	98(mil)	193(mil)	148(mil)
Average SPAD / year	7	13	61

DECADE 1926 - 1936: *Pre War, Depressed Economy, Crude Technology / Infrastructure.*

DECADE 1951 - 1961: *Post War, Railway Boom, Somewhat improved Technology / Infrastructure*

DECADE 1981 - 1991: *Political, "Winds of Change", Relatively Hi-Tech.*

QUESTIONNAIRE COMPOSITION

SLEEP DISTURBANCE SCALE (REVISED)	SSI
SLEEP APNEA SCALE	BENTLEY
EPWORTH SLEEPINESS SCALE	JOHNS
PHYSICAL HEALTH QUESTIONNAIRE	SSI
THE GENERAL MENTAL HEALTH QUESTIONNAIRE	SSI
COGNITIVE - SOMATIC ANXIETY SCALE	SSI
COPING STRATEGIES INVENTORY	SSI
COMPOSITE MORNINGNESS / EVENINGNESS QUESTIONNAIRE	SSI
CIRCADIAN TYPE INVENTORY	SSI
EYSENCK PERSONALITY INVENTORY	SSI
MINNESOTA SATISFACTION QUESTIONNAIRE	WEISS
ALIENATION / INVOLVEMENT QUESTIONNAIRE	LEFKOWITZ
WORKING ENVIRONMENT / ERGONOMIC FACTORS QUESTIONNAIRE	VAN TONDER
OPEN ENDED QUESTIONNAIRE	

TOTAL OF 411 QUESTIONS

OVERHEAD NO 11

FREQUENCIES OF TRAIN DRIVERS WHO HAD BEEN TREATED FOR PARTICULAR MEDICAL CONDITIONS

MEDICAL CONDITION	*PERCENTAGE RESPONSE*
Chronic back pain *	27%
Chronic stomach cramps *	17%
Gall stones	4%
Sinus trouble *	39%
Asthma	6%
Chest pain (angina)	8%
Heart attack	1%
Hypertension *	18%
Irregular heartbeat	4%
High cholesterol	12%
Diabetes	3%
Bladder infections *	22%
Kidney stones *	14%
Eczema	9%
Depression	10%
Chronic anxiety	4%
Headaches *	29%
Cancer	1%
Chronic fatigue	7%
Anaemia	1%
Gastric or duodenal ulcers *	25%
Periodic limb movement disorder *	25%

* INDICATES SIGNIFICANTLY HIGHER THAN FOR THE GENERAL POPULATION (WHITE, MALE)

OVERHEAD NO 12

NOTEWORTHY CONDITIONS EXPERIENCED IN THE CAB

1. *DROWSINESS*
2. *URGE TO URINATE*
3. *PAIN IN THE LOWER BACK*
4. *PAIN IN THE LEGS*
5. *FRUSTRATION*
6. *FEAR FOR THEIR SAFETY*

THE APPROXIMATE RESULTS FOR THE MOST COMMON SYMPTOMS OF SLEEP APNEA ARE AS FOLLOWS:

SYMPTOM	RESULT
Waking up gasping or choking	*9%*
Waking up sweating	*34%*
Restlessness while sleeping	*35%*
Severe snoring	*53%*
Holding of breath while asleep	*17%*

In the morning:

Headache	*28%*
Thick head	*36%*
Dry mouth / Throat	*50%*
Saliva or wet patch on the pillow	*31%*

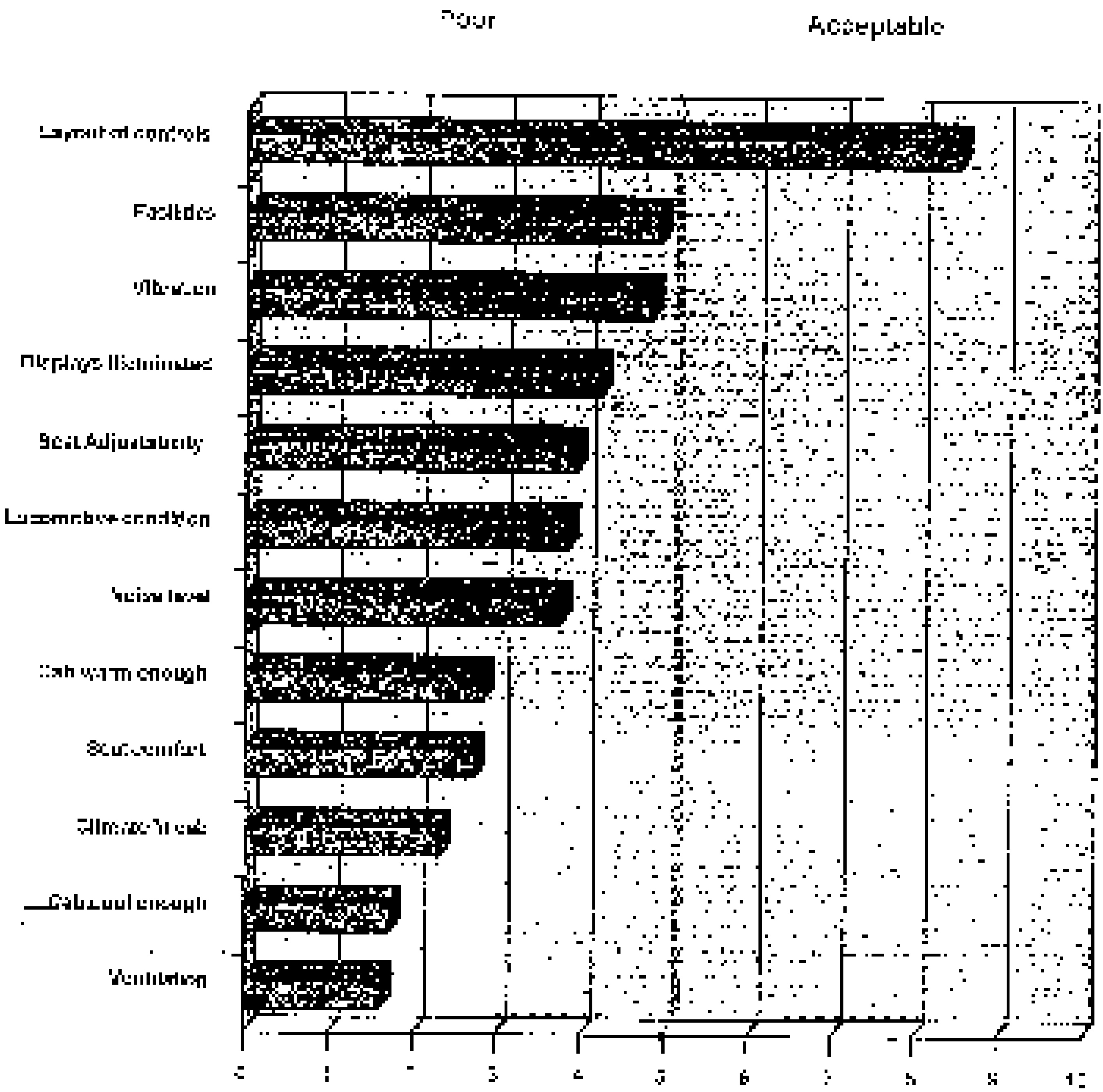
OVERHEAD NO. 14

THE SIX ABSOLUTES OF SAFETY AND HEALTH

- THERE IS NO PERFECT SAFETY IN TRANSPORT
- THE HUMAN ELEMENT CANNOT BE ELIMINATED
- THERE IS AN ASYMMETRY OF CULTURES THAT SEES THINGS DIFFERENTLY
- PEOPLE CANNOT BE KEPT IGNORANT OF THEIR ENVIRONMENT
- SAFETY AND HEALTH ARE MUTUALLY INCLUSIVE CONCEPTS.
- ACCIDENTS ARE NOT CAUSED BY CONDITIONS OR BY THINGS

(SIR ALASTAIR MORTON, 1995)
(H.W. HEINRICH, ET AL., 1980)

Drivers Perception of the Cab Environment



OVERHEAD NO. 16

1996 CAPE TOWN

7 October - 9 October 1996
The Lord Charles Hotel, Cape Town, South Africa

Paper 9642

Hans Peter Hadorn

The SBB rescue-train management system

Publisher
© [illegible] International Rail Safety Conference

CURRICULUM VITAE

Hans-Peter Hadorn

Hans-Peter Hadorn graduated from the University of Bern with a degree in Economics. He began working as a Junior assistant in a Universal Bank.

1984 - 87
SBB: Financial division controller in political economics

1988 - 91
SBB: Cabinet Manager of the CEO

1992 - 95
SBB: International Policy Officer, Representative to the Community of European Railways (CER)

1995 -
SBB: Head of the Safety division (HQ): responsible for corporate safety policy / standards.

The SBB Rescue-train Management System

by

Hans-Peter Hadorn

Head of Safety Division
Swiss Federal Railways, CH-Bern

International Safety Conference, Cape Town, 1996-10-07

The SBB rescue-train management-system

by Hans-Peter Hedorn, Head of Safety Division, Swiss Federal Railways, CH-Bern

1. Initial situation

In 1976, the SBB have put into service 11 rescue and fire-fighting trains. This in consequence of the following facts, among others

- No public emergency service had suitable material for intervention in case of emergencies in tunnels and suburban areas.

- For fire-fighting in tunnels, and at many places on the open line, no water was available.

- The SBB as owner wanted to assume responsibility, as it is stipulated as a guiding principle in legal prescriptions.

With an experience gathered during 20 years now, with up to 70 missions completed per year, this tool can be described as utterly useful.

The existing rescue and fire-fighting trains (LRZ) are continually held up to-date in their technical equipment, so as to be able to fully satisfy the requirements in regard to rescue, oil pollution and fire-fighting, both from the personal and material point of view.

It is a serious disadvantage in the opinion of experts, that the operational areas of the LRZ are so extensive, because of time-consuming transfers from their home base to the accident sites.
In the case of an accident, the time factor is of decisive importance. To downsize the operational areas, with consequential shortening of the time needed to reach the site, specially in tunnels and otherwise inaccessible open line sections, is therefore a major requirement of the new concept.

The frame conditions shown initially, have no doubt accentuated themselves in recent years, so that today the following factors have to be considered additionally:

- Increase of the tunnel share in the whole network in consequence of planned new constructions, and projects already under construction

- Considerable increase in the transport volume of dangerous goods, namely in piggyback and container transport

- The new government legislation on accident prevention strengthens the request addressed to the SBB to provide low-floor wagons for the transportation of road vehicles dedicated for fighting against hazards with chemicals

- Cantonal (= regional) authorities strongly request that in all new tunnel projects, installation of fire water pipes with water constantly under pressure must be foreseen, with hydrants and devices for increasing water pressure, and with connection to the public water supply system.

- According to the new ordinance on accident prevention, SBB emergency services must be incorporated into the concept of the Federal Office of Transport for the reduction of incidents.

- Coming into force of the ordinance on accident prevention on 1st April 1991, obliging the SBB to immediately fight against incidents that are potentially hazardous to safety.

Since a tariff supplement is asked for the transportation of dangerous goods, the client expects that risks are kept at an acceptable level through prevention and intervention, and that unacceptable risks are further lowered through sensible investments.

Further, past rescue and fire-fighting interventions carried out, show that to master the effects of accidents in subterranian trafficways, is very delicate and without adequate vehicles very difficult, if not nearly impossible

2. The new concept

Seen this starting situation, the General Management of SBB was induced to place an order to assess the existing rescue organisation. In particular it should be examined if the existing concept in regard to number and equipment of the LRZ, still meets modern requirements and legal obligations.

The following points were fixed as targets for the new concept:

- Fast and effective limitation of the consequences for humans, for the environment, and for the company, after a damaging event has occurred.

  Making sure that the first intervention is effected with the LRZ in tunnels and on line sectors unaccessible for road vehicles, in cooperation with the public emergency services.

- Support of the public emergency services when damages occur at other areas of SBB, and at objects that border the railway-line access.

- Assessment of alternative solutions.

2.1 Alternative solutions

As alternatives to the choice of track-bound means of intervention LRZ, three possibilities were examined more closely. They were

Combi vehicle road / rail

Instead of additional LRZ, tank wagons for fire-fighting, pioneer and rescue vehicles capable to run on the road and on rails, would be purchased and stationed at home bases of professional fire brigades and their support bases. The vehicles can also be used for intervention outside the SBB.

Apart from the advantage of relatively big flexibility of intervention, this variant however presents weighty disadvantages.
These are above all the investments for the construction of additional fire brigade sheds, installations for the transfer to rails, etc. and the obligation for the SBB to nevertheless place own personnel at disposal.

Further, tank fire engines are also subjected to the weight limit of 28 tons on the road, so that they can carry 5 - 6 m³ at the most, an amount that is used up within 2 - 3 minutes.

Container systems:

Standardised containers are equipped with rescue and fire-fighting material, and are stationed at locations from where it is possible to transport it by rail, road or helicopter to the place of the accident.

This variant also needs big investments (loading facilities, carrier and towing vehicles). The biggest disadvantage is however its volume and weight limitation so that the effort needed to move it remains justified.
Furthermore this option, at least as far as helicopter transport is concerned, depends strongly on weather conditions.

Transportation by Hupac

At defined locations, 3 - 5 Hupac wagons each are permanently kept in reserve to be on the ready to load the road vehicles of public emergency services.
This variant also needs big investments in the construction of loading ramps, and for the procurement of new piggyback wagons.
The biggest disadvantage however is the non-existence of a standardisation of the sizes of road vehicles (structure-gauge).

All three variants have decisive disadvantages as compared with the LRZ system, so that it was decided to pursue the option of an increase of the number of LRZ.

2.2 Locations of the home bases for the vehicles

An analysis of the situation showed that six additional bases would represent an optimal synthesis of effort and effect. The following criteria were studied:

- number of new tunnels and line sectors having no road access.

- risks connected with transportation of dangerous goods (incl. piggyback corridor);

- downsizing of operational areas and consequently faster intervention;

- locations of locomotive depots (with diesel engines);

- stations and depots with existing works protection brigades.

By maintaining the existing LRZ, and buying additional trains, not only sizeable, but necessary improvements were realised in the field of accident intervention. These improvements are:

- smaller intervention areas - less time needed to reach the accident site - bigger rescue chances - better limitation of damage.

- quicker first interventions in tunnels and line sectors not accessible by road, in cooperation with external emergency organisations.

3. The new rescue and fire-fighting train (LRZ 96)

When the new concept was worked out (basis: increase of the number of LRZ), the following variants were examined:

- previous concept with rescue and fire-fighting wagon (including existing intervention wagon for oil hazards), but adapted to modern technology;

- previous concept with rescue and fire-fighting wagon, but adapted to modern technology. Instead of the previous intervention wagon for oil hazards, bigger wagons are used, allowing a new distribution of the carried material (material of the road vehicles of the chemical hazards brigade);

- new fire-fighting wagon and a gas-tight rescue container on standard chassis and intervention wagon for oil hazards).

A cost/benefit analysis showed that the third variant is likely to bring the best results.

3.1 The LRZ 96

The six LRZ to be delivered until end of 1996, complete the previous fleet of eleven units of intervention and rescue vehicles, existing since 1976. Thanks to the expansion of the fleet, the intervention areas could be reduced. This means shorter distances and therefore quicker help.

The LRZ are composed of a tank wagon for fire-fighting, a tools wagon and a rescue wagon. The train composition with a total weight of 150 tons contains a multitude of technical intervention means, indispensable in case of emergency. Each new LRZ costs about 2 Mio. US-$.

The tank wagon for fire-fighting

This wagon has a pump with a guaranteed pumping capacity of 6 000 litres/minute, at a pressure of 10 bar. The two water throwers mounted on the roof have a pumping capacity of 2 400 l/min. and have a jet reach of 70 metres for water, and 50 metres for foam. More technical details are contained in the annex.

The tools wagon

Unlike the old one, the new tools wagon contains the equipment of an oil spillage fighting wagon.
Heavy equipment (movable powder extinguishers, emergency power generators, etc.) can be loaded and unloaded with a swivel crane.
The whole communication equipment is now fitted into the tools wagon, and includes:
- a mobile station and portable radio sets
- the internal-circuit radio for the LRZ,
- the SBB operational radio,
- and a wireless telephone "Natel C"
More details are contained in the annex.

The rescue wagon

Construction and equipment of the rescue wagon is completely new. It is a gas-tight rescue container with air curtain device and special transfer canal. In the container, around 60 people can be supplied with breathing air during three hours. This makes it unnecessary that rescued persons have to wear breathing masks, and problems with mask not fitting every head size and not being air-tight, do not occur.
More details are contained in the annex.

4. Effects in other fields of action

First effects of the new LRZ concept emerge in the planning of the new transalpine lines (NEAT).
Safety on this new route, and particularly in the 57 km long Gotthard base tunnel, shall be provided with constructive measures concerning the infrastructure, and with means of intervention (in other words: rescue and fire-fighting trains).
Thus, in today's view, major investments into infrastructure can be avoided, without reducing the safety standard as a whole (=result of the risk analysis).

Annex 1 Some figures on the SBB network

Length of lines	3'000 km 100 % electrified (alternating current) 264 tunnels with a combined length of 211 km 7'000 bridges and road overpasses
Traffic	around 8'700 trains per day (of which 2'500 goods trains) Average train density 110 trains per day and per line
Passengers transported 1995	253.2 mio Passengerkm = 11'711 mio.
Goods transported 1995	47.4 mio. tons. of which 9 mio. tons were dangerous goods Tonnskm = 9157 mio.

Infrastructure expansion (high speed lines)

"Bahn 2000": 117 km new lines, of which 48 km in tunnels or otherwise
(30 min -interval on covered.
main lines)

Alptransit (Link between Northern and Southern Europe through the Alps New lines totalling 171 km, of which 119 km in tunnels or otherwise covered)

Annex 2 The fire protection service of the SBB

Definition:
The fire protection brigades of the SBB are internal task formations on a militia basis, based on provisions of the railway law, the law for the prevention of water pollution, the ordinance on accident prevention and partly on cantonal legislation on fire protection.

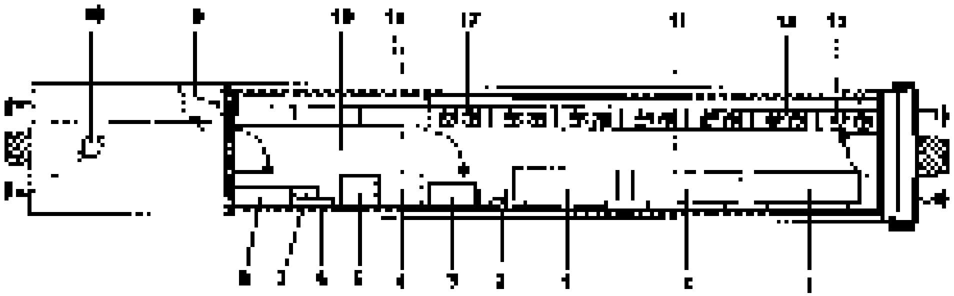
Organisation:
- 59 fire protection brigades
- 2'032 firemen

Assignment:
The fire protection service is charged to prepare and carry out measures in the following fields:

- giving the alarm internally and externally;
- protection, rescue and taking care of own personnel and other people within the precincts of the SBB
- protection of tangible property;
- fire protection and fire-fighting;
- limitation of damage after accidents, and help in restoring normal operating conditions as soon as possible;
- protection of the environment after accidents that cause damages to dangerous materials;
- supporting external emergency organisations in their fight against the effects of damage-causing accidents in the immediate vicinity of railway property.

Annex 3

RETTUNGSWAGEN



Legende

LÖSCH- UND RETTUNGSZUG '96 (LRZ)

1. Zweck

2. Ziel

4. Organisation

4. Personal

5. Material

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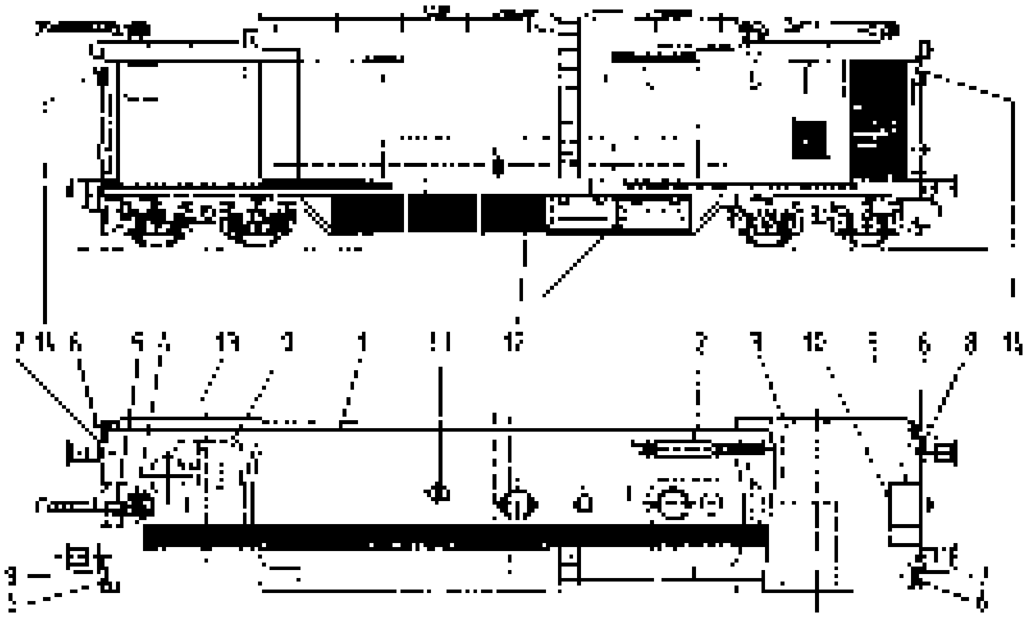
LÖSCH- UND RETTUNGSZUG [illegible]

TANKLÖSCHWAGEN



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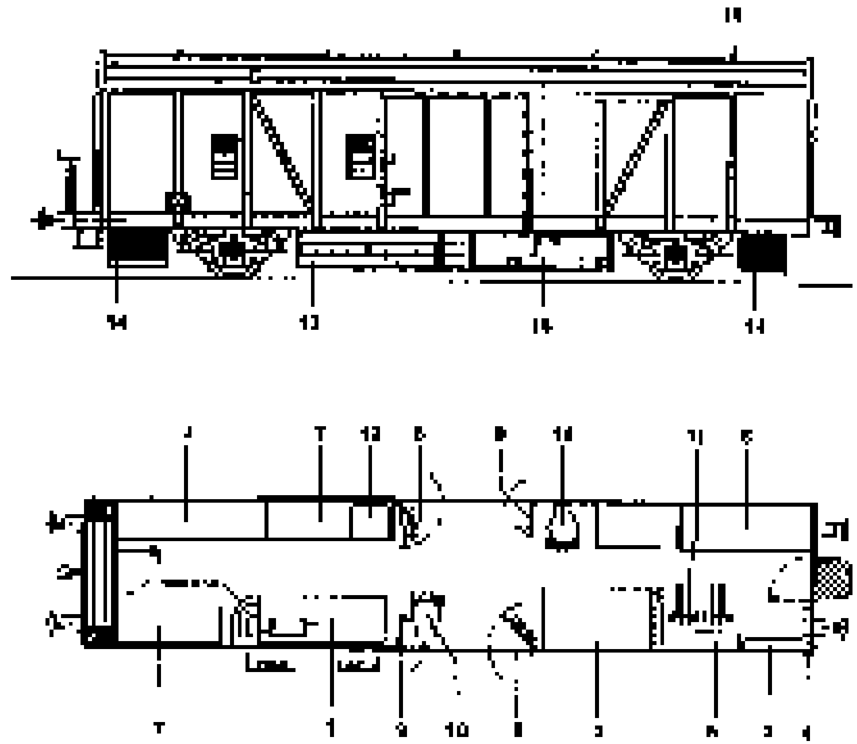
LÖSCH- UND RETTUNGSZUG [illegible]

GERÄTEWAGEN



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Anlage 4: Technische Daten LRZ 96

Tanklöschwagen

Dieselmotor	Typ		BF8 M 1015
	Kühlsystem		Wasser
	Leistung		250 kW
Pumpenaggregat	Typ		FP 60/10
	Normaldruck 8 bar		6 000 l/min
	Hochdruck 40 bar		300 l/min
Löschmittel	Wasser	44'000 l	
	Schaummittel	1'000 l	
	Pulver		1 x 500 kg
	Treibgas Pulverlöscher		Stickstoff
Wasserwerfer Anzahl		2	
	Leistung		je 2 400 l/min
	Antrieb	elektrische Stellmotoren	
Atemluftvorrat		12 Flaschen zu 50 Liter	
			300 bar, total 162'500 l

Gerätewagen

Stromversorgung im Einsatz		Ortsnetz 230/400 Volt	
			Motor/Generatorgruppe 80 kVA
Dieselmotor	Typ		Deutz BF4M 1012 C
	Kühlsystem		Wasser
	Leistung		70 kW
Generator	Typ		Leroy-Somer
Atemluftkompressor	Typ		KAP 220-3/E-H
	Betriebsdruck	200 bar	
	Leistung		550 l/min
Atemluftvorrat		6 Flaschen zu 50 Liter 300 bar	
			total 108'000 l
Weiteres Material	2 fahrbare Pulverlöscher 50 kg		
	2 fahrbare Wasserlöschgeräte		
	diverse Fernmeldeeinrichtungen		

Rettungswagen

Atemschutz Schleuse	geschlossener Rettungscontainer mit Luftschleiergerät und		
Atemschutzgeräte für Besatzung			14
Atemluftvorrat		36 Flaschen zu 50 Liter 300 bar	
			total 481'000 Liter
Weiteres Material	1 mobile Motorspritze		
	1 mobile Notstromgruppe		
	Definitivausrüstung eines bisherigen Oelwehrwagens		

Lehrgang
für das
Bundespersonal

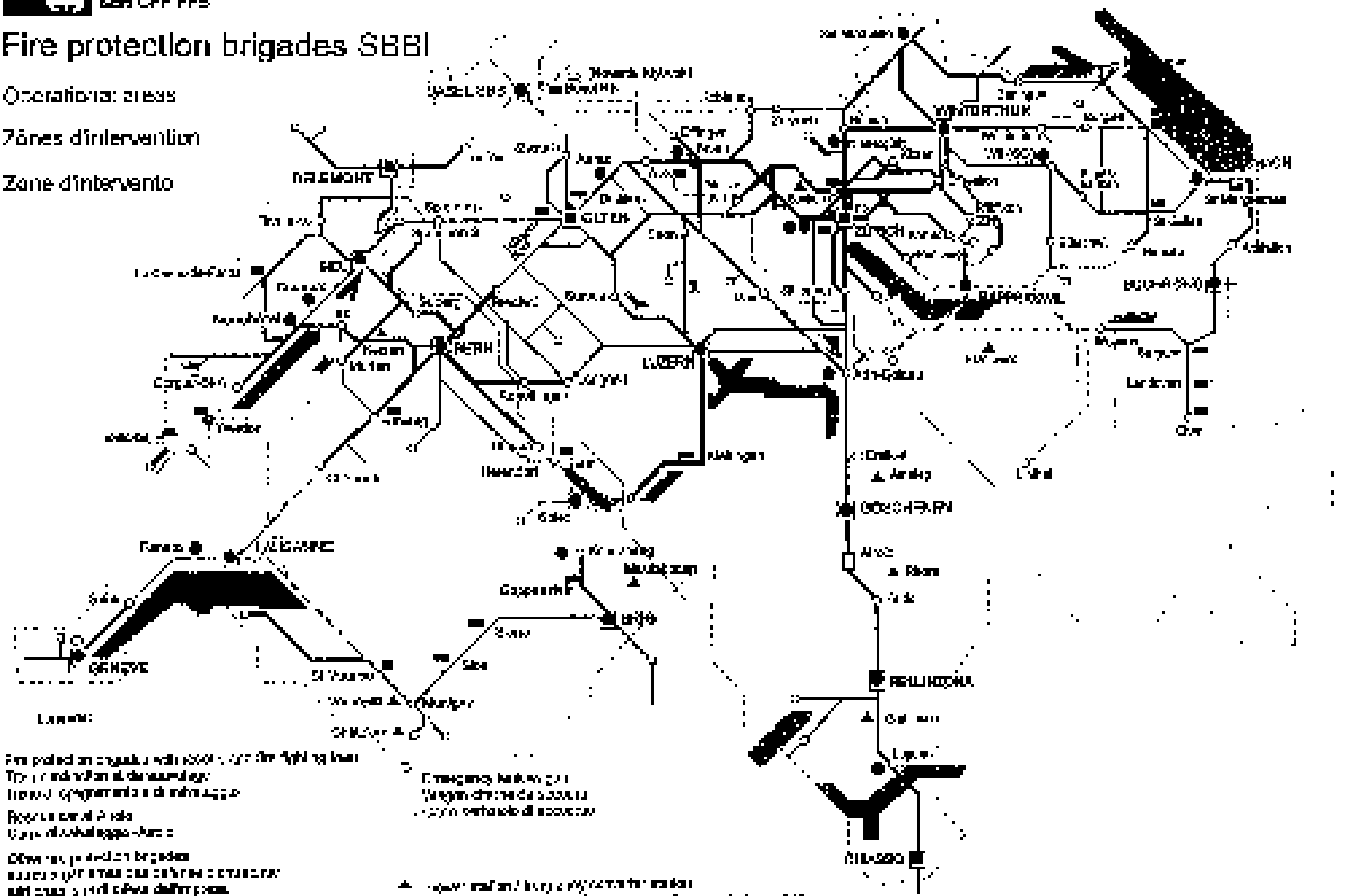
SBB CFF FFS

Fire protection brigades SBBI

Operational areas

Zônes d'intervention

Zone d'intervento



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Annex 6

1996 CAPE TOWN

5 October - 9 October 1996
The Lord Charles Hotel, Cape Town, South Africa

Paper 9643

Daryl Byrne

An Overview of Rail Safety in Australia

INTERNATIONAL RAILWAY SAFETY CONFERENCE

SOMERSET WEST , SOUTH AFRICA

1996

Daryl Byrne
Director Public Transport Safety
Department of Infrastructure
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Melbourne, Victoria

TABLE OF CONTENTS

1. VICTORIAN SAFETY ACCREDITATION

Victoria has adopted a co-regulatory approach to safety accreditation in which the industry establishes, implements and maintains the standards to which it intends to operate. The Department of Infrastructure ensures that the organisations involved directly in the industry conform to those standards.

A vital component of this approach is for the companies to not merely maintain the current status but to engage in an active continuous improvement program.

To obtain accreditation Railway organisations are required to :

- describe the activities which they intend to undertake
- establish the processes through which they intend to safely manage their activities
- demonstrate through a process of risk management that the activities do not expose the community to unacceptable risks
- demonstrate through a process of audit and review that the processes established to control the risks are being followed.

The majority of organisations operating in Victoria have established comprehensive safety systems where core activities have been identified and procedures reasonably documented and generally followed by staff in carrying out their duties.

The process followed by the companies has been the documentation of the existing procedures with little appreciation of why the procedures have been established or an assessment made of their effectiveness.

To support the co-regulatory approach the adoption of various programs and the development and implementation of others have been supported.

The various programs are:

- Australian Standards AS 4292.1 - 1995 Railway safety management
- Intergovernmental Agreement on Rail Safety
- Australian Standards AS/NZS ISO 9002-1994 Quality assurance systems
- Training in risk management techniques by ALARA Risk Management Services
- Training in auditing techniques by Stuart Quality Services

2. AUSTRALIAN SAFETY STANDARDS

The establishment of safety standards has been undertaken by the Australasian Railway Association in conjunction with Standards Association Australia.

Australian Standard AS 4292 Railway safety management. Part 1: General and Interstate Requirements was issued in June 1995.

The standard provides a uniform set of safety standards which simplify the development of safety management systems.

The standard will eventually consist of six parts :

Part 1 - General and Interstate Requirements
(Appendix A - Front page and Contents Pages of AS 4292.1)

Part 2 - Track, civil and electrical traction infrastructure
(Appendix B - Draft Front page & Contents Pages of AS4292.2)

Part 3 - Rolling Stock
(Appendix C - Draft Front page & Contents Pages of AS4292.3)

Part 4 - Signalling and Telecommunications systems & equipment
(Appendix D - Draft Front page & Contents Pages of AS4292.4)

Part 5 - Operational systems
(Appendix E - Draft Front page & Contents Pages of AS4292.5)

Part 6 - Interface with other transport systems - still being developed

NOTE - Parts 2 to 5 were distributed for public comment during April/May 1996. The Standards Australia Committee are currently reviewing the comment and it is anticipated that these standards will be published in the first quarter of 1997.

3. INTERGOVERNMENTAL AGREEMENT ON RAIL SAFETY

(Appendix F - Intergovernmental Agreement on Rail Safety - Format of Agreement)

(Appendix G – Intergovernmental Agreement on Rail Safety – Contents pages and Part 2 of the Rules of Administration - Mutual Recognition of Accredited Safety Management Systems)

As part of the process of freeing up access to the railway infrastructure, the state governments along with the commonwealth government have entered into a agreement calling for the mutual recognition of safety accreditation granted by any of the existing state Accrediting authorities.

To facilitate this agreement the Australian Rail safety management standard is being called up in legislation throughout Australia.

If companies adopt this standard the safety accreditation granted by any one state will be accepted by all States.

The agreement also provides for the sharing of rail accident and incident data, the establishment of independent investigations and the adoption of a common approach to Compliance Inspections (Auditing).

3.1 INVESTIGATIONS

(Appendix H - Intergovernmental Agreement on Rail Safety - Contents pages and extract of Part 3 of the Notes of Administration - Investigations)

Experienced railway investigators have been nominated by each state to be utilised as independent investigators when requested by interstate operators involved in railway accidents. To support this, the Commonwealth Government has nominated investigators from the Bureau of Air Safety Investigation experienced in Human Factors.

Although the IGA was entered into principally to address interstate operators and formal arrangements are still being put into place, investigators from the pool have already been used in Western Australia and Queensland to investigate main line accidents. The accident in Western Australia resulted in the death of a train driver and authorised passenger in the driver's cabin

3.2 INFORMATION EXCHANGE

(Appendix I - Intergovernmental Agreement on Rail Safety - Contents pages and extract of Part 4 of the Notes of Administration - Information Exchange)

The information agreed to be exchanged form part of the appendices of the standard.

The first exchange of information will take place in either December 1996 or January 1997. The normalising factors have been agreed and a concerted effort is being made to adopt the same definitions and reporting format. The information will be collated by each state jurisdiction and distributed through the Australian Railway Association.

3.5 AUDIT (COMPLIANCE INSPECTIONS)

(Appendix I - Intergovernmental Agreement on Rail Safety - Contents pages and extract of Part 5 of the Notes of Administration - Compliance Inspections)

Audits will be conducted:

- before an accreditation is granted to evaluate the level of competency and expertise of the applicant to undertake the activities for which they are seeking accreditation and
- following the granting of accreditation to ensure that the systems detailed in the accreditation are being complied with.

Audits will be conducted into all aspects of the safety systems to ensure that appropriate standards are in place and that those standards are being met.

4. RISK MANAGEMENT

The practical use of Risk Management techniques within the railway industry in Victoria was generally used for the justification of new projects and the allocation of capital funds and occasionally in the development stages of new projects.

Risk Management was rarely seen as simply as "a good management tool". The majority of the line supervisors had no appreciation of the concepts or techniques although it is an accreditation requirement for companies to identify and control their principal risks.

To overcome this lack of appreciation and skills a training course in "risk management" techniques was developed in association with ALARA Risk Management Services Pty. Ltd.

4.1 RISK MANAGEMENT TRAINING

ALARA Risk Management Services has extensive experience in the mining, petro-chemical, transport and process industries in the United Kingdom and Australia.

The training program consists of three modules

Risk Management - Concepts and Practice

Risk Management - Tools Applications and Systems

Risk Management - Systems Safety Accident Investigation

4.1 : Module 1 - CONCEPTS AND PRACTICE

(Appendix V - Course Module Format & Objectives)

The first module was to introduce the concept of risk management at it's most basic.

The module is run over two consecutive days and it's objectives are for participants to:

- describe risk analysis and loss control concepts
- identify organisational factors that influence the success of risk analysis
- understand a generic risk analysis methodology
- apply specific tools to analyse risks
- assess risk analysis requirements and support sources

4.7.2 Module 2 - TOOLS, APPLICATION & SYSTEMS

(Appendix 1 - Course/Module Objectives)

The objects of this module was to build on the basics of risk analysis by introducing new tools and techniques and to encourage practice of the techniques. The module is run of one day a week spread over three consecutive weeks. A prerequisite for attending this module is the successful completion of the first module.

This module is divided into three discrete parts

Day 1 - Tools and Techniques

- Fundamentals of Probability
- Fault Tree Analysis & Failure modes
- Human error as a failure mode.

Day 2 - Application

- Team based risk exercises
- Case study review

Day 3 - Systems

- complete case study review
- Australian Standard AS/NZS 4360 - Risk Management
- Acceptability
- Systems Planning and Implementation

4.1.3 Module 3 - SYSTEMS SAFETY ACCIDENT INVESTIGATION

(Appendix 16 - Extract of System Safety Accident Investigation Skills Workshop.)

This module is currently being developed. It will compose of three days training in a similar fashion to Module No. 2. Again the prerequisite of this module is the completion of the first two modules.

The objects of this module is to continue to build on the techniques already learnt and to promote the use of the skills obtained in a practical situations.

Successful completion of the three modules will be accepted as suitable competency for investigating railway incidents and accidents.

The current thrust of many incident investigations is still to determine the cause of the incident only as far as it was needed to establish blame. There is little understanding that there may be systemic or organisation problems that could have contributed to the incident.

Currently 300 supervisory staff from within the Public Transport Corporation, the National Rail Corporation and West Coast Railway have successfully completed this module.

5. AUDITING

Similarly to risk management the practical use of auditing techniques was generally only used in the financial sense, in the detection of misappropriation of funds, during or following special projects.

Outside of employee occupational health and safety, auditing was rarely used to assess safety performance or to identify system deficiencies. Audits of safety activities was very much the role of specialist "safety advisers" who were usually union trained and often union orientated and devoted to employee occupational health and safety issues - "slips, trips & falls". They were frequently used by line management to demonstrate compliance with occupational health and safety legislation.

5.1 Quality Auditing

(Appendix N - Extract of Quality Assurance Internal Auditor Training

The PTC developed an audit training course in association with Smart Quality Associates Pty. Ltd.

The objectives of the course are

- to provide a basic understanding of internal quality systems auditing;
- explain different types of audit and their application;

- explain and demonstrate the techniques involved in planning, executing, reporting and follow up of audits;
- give delegates sufficient basic training to be able to participate in Quality Management Systems Internal auditing;

The program was developed as part of the drive towards quality in the vehicle maintenance area however most of the corporation's internal audit staff have now been trained in quality auditing.

The majority of the rail vehicle maintenance and the infrastructure management areas have been certified to AS/NZS ISO 9002:1994 Quality Systems - Model for quality assurance in production, installation and servicing.

AUSTRALIAN STANDARD AS 4292.1 - 1995

RAILWAY SAFETY MANAGEMENT

Part 1 : General and interstate requirements

AS 4292.1—1995

Australian Standard®

Railway safety management

Part 1: General and interstate requirements

STANDARDS AUSTRALIA

PREFACE

This Standard was prepared by the Standards Australia Committee on Railway Safety in response to a request by the Railways of Australia Committee, with support from railway regulators, to prepare a uniform set of safety standards to simplify the development of safety management systems. The Standards were also intended to facilitate accreditation of owners and operators on any railway, and to facilitate the safety accreditation of railway industry participants.

This Standard is Part 1 of a series of Standards dealing with requirements of a railway safety management system. When complete the series will comprise:

Part 2: Track, civil and electrical infrastructure
Part 3: Rolling stock
Part 4: Signalling and telecommunications systems and equipment
Part 5: Operational systems
Part 6: Interface with other transport systems

Section 3 of this Standard may be subject to revision in a future edition as a result of publication of the proposed Australian/New Zealand Standard on Risk management.

The Committee recommends that this Standard be implemented from the date of its publication for railways forming part of the designated interstate system as defined in the Standard. In relation to intrastate and other railways, it is noted by the Committee that implementation of the Standard may need to be staged and the Standard modified or subsidiary Standards developed if required.

The terms 'normative' and 'informative' have been used in this Standard to define the application of the appendix to which they apply. A 'normative' appendix is an integral part of a Standard, whereas an 'informative' appendix is only for information and guidance.

CONTENTS

[illegible] AS 4292.1—1995

FOREWORD

This Standard has been prepared primarily with a view to achieving uniformity in the management of railway safety both as a general principle and with specific reference to the coordination of railway industry participants.

The safety objective of the railway industry, in common with all responsible industry, is to minimize the risk of harm to people and damage to property.

Railway safety management aims to ensure that railways take appropriate action to limit the risk of injury to persons or damage to property to acceptable levels. This approach recognizes that, while there is an ideal level of safety, the practical costs of attaining this ideal might far outweigh the benefits, and limit the viability of railway operations. It is also well understood that an operator protects its commercial interest by running a safe railway.

Railway safety has a relationship with workplace health and safety. Occupational health and safety (OHS) is governed by specific legislation and is therefore not the primary objective of this Standard. However, as it would be a consequence of preparing, implementing and maintaining a railway safety management system in accordance with this Standard, its importance is recognized within the safety principles of the Standard. Security issues are distinct from safety elements and are outside the scope of this Standard.

This Standard also includes common interface requirements for owners and operators of the designated interstate system. The philosophy adopted in identifying their particular requirements has been that whenever this interface occurs, observance of all of the generally applicable requirements of this Standard by each party will ensure safe interfacing for the greater part. It is only in those relatively few areas where, despite the above, a mismatch of current practices or dimensional requirements could still occur, that common essential requirements have been identified and specified.

DRAFT AUSTRALIAN STANDARD AS 4292.2

RAILWAY SAFETY MANAGEMENT

DR 96113 Part 2 : Track, Civil and Electrical Infrastructure

ATTENTION

DR 96113—96116

DRAFT AUSTRALIAN STANDARD FOR COMMENT

LIABLE TO ALTERATION—DO NOT USE AS A STANDARD

DATE OF ISSUE:	1 MAY 1996
CLOSING DATE FOR COMMENT:	30 JUNE 1996
DR 96113—96116	RAILWAY SAFETY MANAGEMENT
DR 96113	PART 2: TRACK, CIVIL AND ELECTRICAL INFRASTRUCTURE (TO BE AS 4292.2)
DR 96114	PART 3: ROLLING STOCK (TO BE AS 4292.3)
DR 96115	PART 4: SIGNALLING AND TELECOMMUNICATIONS SYSTEMS AND EQUIPMENT (TO BE AS 4292.4)
DR 96116	PART 5: OPERATIONAL SYSTEMS (TO BE AS 4292.5)

PRICE CODE: C

STANDARDS AUSTRALIA

Committee-in-Confidence
Issued: July 1996

STANDARDS AUSTRALIA
COMMITTEE ME/79—RAILWAY SAFETY

SUMMARY OF COMMENT

ON

DR 96113-96115: RAILWAY SAFETY MANAGEMENT
PART 2: TRACK, CIVIL AND ELECTRICAL INFRASTRUCTURE
PART 3: ROLLING STOCK
PART 4: SIGNALLING AND TELECOMMUNICATIONS SYSTEMS AND EQUIPMENT
PART 5: OPERATIONAL SYSTEMS

The following organizations commented on the draft.

ACCI	ACCI Comment submitted by Mr R Mitchell, BHP
AN	Australian National
BARCLAY	Barclay Mowlem Construction Ltd
BTM	Ballarat Tramway Museum Inc
CESC	ARA Civil Engineering Steering Committee
DON	Don River Railway
ELEC WG	ARA Electrical Working Group
GECAA	GEC Alsthom Australia
MAINTRAIN	Maintrain Auburn
MESC	ARA Mechanical Engineering Steering Committee
OPS WG	ARA Operations Working Group
PTC OLIVER	Public Transport Corporation, Victoria (Mr Oliver)
PTC BELL	Public Transport Corporation, Victoria (Mr Bell)
PTU	Public Transport Union
QR MOORE	Queensland Rail (Mr Moore)
QR JONES	Queensland Rail (Messrs Jones and Marsden)
QR GALVIN	Queensland Rail (Mr Galvin)
REDEI	Andrew Redei and Associates
RPE	Railway Project Engineering Pty ltd, Taree NSW
S&T WG	ARA S&T Working Group
SIEMENS	Siemens Ltd. Transportation Systems
SRA ALLISON	State Rail Authority, NSW (Mr Allison)
SRA LOGAN	State Rail Authority, NSW (Mr Logan)
SRA ROBINSON	State Rail Authority, NSW (Mr Robinson)
SRA LOVAT	State Rail Authority, NSW (Mr Lovat)
SRA HENRY	State Rail Authority, NSW (Mr Henry)
SUGAR	Australian Sugar Milling Council
TRANSAD	TransAdelaide
USS	Union Switch and Signal Pty Ltd
WESTRAIL WEAIRE	Westrail (Mr Weaire)
WESTRAIL GOBETZ	Westrail (Mr Gobetz)
WSA TAS	Workplace Standards Authority, Tasmania

DRAFT FOR COMMENT

STANDARDS AUSTRALIA

Committee ME/79—Railway safety

DRAFT

Australian Standard

Railway safety management

Part 2: Track, civil and electrical infrastructure

This draft has been prepared in order to set requirements and provide guidelines for the preparation or adoption of railway safety standards and procedures complying with the relevant requirements of AS 4292.1, in the subject area covered by this Part.

Comment on the draft is invited from persons and organizations concerned with the subject. It would be appreciated if those submitting comment would follow the guidelines given on the inside front cover.

Attention is drawn to the fact that this document is a draft Australian Standard only and is liable to alteration in the light of comment received. It is not to be regarded as an Australian Standard until finally issued as such by Standards Australia.

PREFACE

This Standard was prepared by the Standards Australia Committee on Railway Safety in conjunction with AS 4292.1 to provide a means of demonstrating compliance with that Standard in the relevant technical area.

This Standard is part of a series of Standards on railway safety. The complete series is as follows:

AS 4292.1 Part 1: General and interface requirements
AS 4292.2 Part 2: Track, civil and electrical infrastructure
AS 4292.3 Part 3: Rolling stock
AS 4292.4 Part 4: Signalling and telecommunications systems and equipment
AS 4292.5 Part 5: Operational systems
AS 4292.6* Part 6: Interface with other transport modes

The terms 'normative' and 'informative' have been used in this Standard to define the application of the appendix to which they apply. A 'normative' appendix is an integral part of a Standard, whereas an 'informative' appendix is only for information and guidance.

* In preparation.

CONTENTS

DRAFT AUSTRALIAN STANDARD AS 4292.3

RAILWAY SAFETY MANAGEMENT

DR 96114 Part 3 : ROLLING STOCK

DRAFT FOR COMMENT

STANDARDS AUSTRALIA

Committee ME/79—Railway Safety

DRAFT

Australian Standard

Railway safety management

Part 3: Rolling stock

This draft has been prepared in order to set requirements and provide guidelines for the preparation or adoption of railway safety standards and procedures complying with the relevant requirements of AS 4292.1, in the subject area covered by this Part.

Comment on the draft is invited from persons and organizations concerned with this subject. It would be appreciated if those submitting comment would follow the guidelines given on the inside front cover.

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PREFACE

This Standard was prepared by the Standards Australia Committee on Railway Safety in conjunction with AS 4292.1 to provide a means of demonstrating compliance with that Standard in the relevant technical area.

This Standard is part of a series of Standards on railway safety. The complete series is as follows:

AS 4292	Railway safety management	
AS 4292.1	Part 1:	General and interstate requirements
AS 4292.2	Part 2:	Track, civil and electrical infrastructure
AS 4292.3	Part 3:	Rolling stock
AS 4292.4	Part 4:	Signalling systems and hardware
AS 4292.5	Part 5:	Operational systems
AS 4292.6*	Part 6:	Interface with other transport systems

The terms 'normative' and 'informative' have been used in this Standard to define the application of the appendix to which they apply. A 'normative' appendix is an integral part of a Standard, whereas an 'informative' appendix is only for information and guidance.

* In preparation.

FOREWORD

A means of complying with this Standard may be by an organisation entering into a commitment to conform to a code of practice which has been deemed by an appropriate authority to comply in respect of the organisation's type of operation. It is envisaged that in time, a range of codes of practice applicable to specific railway activities may be developed to address different types of railway operation such as tourist/heritage, short haul and advanced technology railways, as well as interstate and urban main line operations.

<u>DRAFTING NOTE:</u> This Foreword has been prepared with a view to reassuring operators of all existing railway systems that their systems can be accommodated within this Standard.

It is acknowledged that in existing railway operations there are practices established through usage as safe. Where this situation applies to an existing railway or where a new railway can be shown to be sufficiently similar to an existing railway which can demonstrate practices which are safe through usage, compliance with this standard may be achieved by adoption or adaptation of these practices.

CONTENTS

DRAFT AUSTRALIAN STANDARD AS 4292.3

RAILWAY SAFETY MANAGEMENT

DR 96115 Part 4 : SIGNALLING AND TELECOMMUNICATIONS SYSTEMS AND EQUIPMENT

DRAFT FOR COMMENT

STANDARDS AUSTRALIA

Committee ME/79—Railway Safety

DRAFT

Australian Standard

Railway safety management

Part 4: Signalling and telecommunications systems and equipment

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This draft has been prepared in order to set minimum requirements/provide guidelines for the preparation or adoption of railway safety standards and procedures complying with the relevant requirements of AS 4292.1 in the subject area covered by this Part.

Comment on the draft is invited from persons and organizations concerned with this subject. It would be appreciated if those submitting comment would follow the guidelines given on the inside front cover.

Attention is drawn to the fact that this document is a draft for a proposed Standard only and is liable to alteration in the light of comment received. It is not to be regarded as an Australian Standard until finally issued as such by Standards Australia.

PREFACE

This Standard was prepared by the Standards Australia Committee on Railway Safety in conjunction with AS 4292.1 to provide a means of demonstrating compliance with that Standard in the relevant technical area.

This Standard is part of a series of Standards on railway safety. The complete series is as follows.

AS 4292.1 Part 1: General and interstate requirements
AS 4292.2 Part 2: Track, civil and electrical infrastructure
AS 4292.3 Part 3: Rolling stock
AS 4292.4 Part 4: Signalling and telecommunications systems and equipment
AS 4292.5 Part 5: Operational systems
AS 4292.6* Part 6: Interface with other transport modes

The term 'informative' has been used in this Standard to define the application of the appendix to which it applies. An 'informative' appendix is only for information and guidance.

* In preparation.

FOREWORD

A means of complying with this Standard may be by an organization entering into a commitment to conform to a code of practice which has been deemed by an appropriate authority to comply in respect of the organization's type of operation. It is envisaged that in time, a range of codes of practice applicable to specific railway activities, may be developed to address different types of railway operation such as high/low density, short haul and advanced technology railways, as well as [illegible] and [illegible] line operations.

DRAFTING NOTE: This Foreword has been prepared with a view to reassuring operators of all existing railway systems that their systems may be accommodated within this Standard.

It is acknowledged that in existing railway operations, there are practices established through usage as safe. Where this situation applies to an existing railway or where a new railway can be shown to be sufficiently similar to an existing railway that can demonstrate practices which are safe through usage, compliance with this standard may be achieved by adoption or adaptation of these practices.

CONTENTS

DRAFT AUSTRALIAN STANDARD AS 4292.5

RAILWAY SAFETY MANAGEMENT

DR 96116 Part 5 - OPERATIONAL SYSTEMS

DRAFT FOR COMMENT

STANDARDS AUSTRALIA

Committee ME/79—Railway Safety

DRAFT

Australian Standard

Railway safety management

Part 5: Operational systems

This draft has been prepared in order to set requirements and provide guidelines for the preparation or adoption of railway safety standards and procedures complying with the relevant requirements of AS 4292.1, in the subject area covered by this Part.

Comment on the draft is invited from persons and organizations concerned with this subject. It would be appreciated if those submitting comment would follow the guidelines given on the inside front cover.

Attention is drawn to the fact that this document is a draft Australian Standard only and is liable to alteration in the light of comment received. It is not to be regarded as an Australian Standard until finally issued as such by Standards Australia.

PREFACE

This Standard was prepared by the Standards Australia Committee on Railway Safety in conjunction with AS 4292.1 to provide a means of demonstrating compliance with the Standard in the relevant technical area.

This Standard is part of a series of Standards on railway safety. The complete series is as follows:

AS		
4292.1	Part 1:	General and interstate requirements
4292.2	Part 2:	Track, civil and electrical infrastructure
4292.3	Part 3:	Rolling stock
4292.4	Part 4:	Signalling and telecommunications systems and equipment
4292.5	Part 5:	Operational systems
4292.6	Part 6:	Interface with other transport systems

Passenger security, whilst considered to be an important operational system aspect, has been deferred to a future edition of the Standard.

The terms 'normative' and 'informative' have been used in this Standard to define the application of the appendix to which they apply. A 'normative' appendix is an integral part of a Standard, whereas an 'informative' appendix is only for information and guidance.

CONTENTS

FOREWORD

A means of complying with this Standard may be by an organisation entering into a commitment to conform to a code of practice which has been deemed by an appropriate authority, to comply in respect of the organisation's type of operation. It is envisaged that in time a range of codes of practice applicable to specific railway activities may be developed to address different types of railway operation such as tourist/heritage, short haul and advanced technology railways, as well as interstate and other main line operations.

<u>DRAFTING NOTE</u>: This Foreword has been prepared with a view to reassuring proprietors of all existing railway systems that their systems can be shown to comply with the Standard.

It is acknowledged that in existing railway operations there are practices established through usage as safe. Where this situation applies to an existing railway or where a new railway can be shown to be sufficiently similar to an existing railway which can demonstrate practices which are safe through usage, compliance with this Standard may be achieved by adoption or adaptation of those practices.

AGREEMENT

Between

The Commonwealth of Australia,

The State of New South Wales,

The State of Victoria,

The State of Queensland,

The State of Western Australia,

The State of South Australia,

The State of Tasmania and

The Northern Territory

In relation to National Rail Safety

THIS AGREEMENT is made the first day of [illegible] 1996

BETWEEN:

THE COMMONWEALTH OF AUSTRALIA,

THE STATE OF NEW SOUTH WALES,

THE STATE OF VICTORIA,

THE STATE OF QUEENSLAND,

THE STATE OF WESTERN AUSTRALIA,

THE STATE OF SOUTH AUSTRALIA,

THE STATE OF TASMANIA and

THE NORTHERN TERRITORY OF AUSTRALIA

WHEREAS:

The Australian Transport Council having endorsed the recommendations of the report "A National Approach to Rail Safety Regulation", the Commonwealth, the States and the Territories of Australia have agreed to establish a cost effective nationally consistent approach to rail safety which ensures there is no barrier to the entry of third party operators based on:

- safety accreditation of railway owners and operators;
- mutual recognition of accreditation between accreditation authorities;
- development and implementation of performance based standards;
- greater accountability and transparency;
- facilitating competition and technical and commercial innovation consistent with safe practice.

INTERGOVERNMENTAL AGREEMENT

ON RAIL SAFETY

NOTES OF ADMINISTRATION

PREFACE

The Notes on Administration for the Intergovernmental Agreement on Rail Safety guide the administration of the Intergovernmental Agreement. They should be read in conjunction with the Agreement and the Australian Standard on Railway safety management AS 4292.

These Notes cover interstate railway operations and are intended primarily as a guide for Accreditation Authorities.

Further information covering the Notes on Administration, the Agreement or the application of the Standard may be obtained by contacting:

New South Wales
Executive Director
Transport Safety Bureau
NSW Department of Transport
227 Elizabeth Street
SYDNEY NSW 2000

Ph: 02 9268 2900
Fax: 02 9268 2925
(GPO Box 1620
SYDNEY NSW 2001)

Queensland
Manager
Rail Safety Accreditation Unit
Land Transport & Safety Division
Queensland Transport
6th Floor, Transport House
230 Brunswick Street
FORTITUDE VALLEY QLD 4006

Ph: 07 3253 4228
Fax: 07 3253 4233
(PO Box 673
FORTITUDE VALLEY QLD 4006)

South Australia
(still being established)

Victoria
Director
Public Transport Safety Directorate
Department of Infrastructure
Level 15, 589 Collins Street
MELBOURNE VIC 3000

Ph: 03 9619 2777
Fax: 03 9619 4963
(GPO Box 4610
MELBOURNE VIC 3000)

Western Australia
General Manager Operations
Westrail
Westrail Centre
West Parade
EAST PERTH WA 6004

Ph: (09) 326 2323
Fax: 09 326 2570
(PO Box S1422
GPO PERTH 6001)

CONTENTS

Appendices

PART 1 - INTRODUCTION

1.1 Background

1.1.1 Commonwealth, State and Territory Transport Ministers at the Australian Transport Council meeting on 21 April 1996 endorsed an Intergovernmental Agreement on Rail Safety relating to interstate rail operations.

1.1.2 The purpose of the Agreement is:

> To establish a cost effective, nationally consistent approach to rail safety which ensures there is no barrier to the entry of third party operators, based on
> - safety accreditation of railway owners and operators,
> - mutual recognition of accreditation between accreditation authorities,
> - development and implementation of performance based standards,
> - greater accountability and transparency,
> - facilitating competition, and technical and commercial innovation consistent with safe practice.

1.1.3 When the Australian Transport Council endorsed the Agreement in April 1996, it provided for the Rail Safety Intergovernmental Agreement and Technical Issues working groups to oversee the implementation of the Rail Safety Agreement and the development of the Rail Safety Standard. It is in this context that the Notes of Administration have been drafted.

1.1.4 The Intergovernmental Agreement came into force on 1 July 1996.

1.1.5 The initial Parties to the Agreement are:

The Commonwealth of Australia,
The State of New South Wales,
The State of Victoria,
The State of Queensland,
The State of Western Australia and
The State of South Australia.

1.1.6 The Northern Territory and the Australian Capital Territory have advised that they will not be Parties to the Agreement at present. Tasmania is still determining its position.

1.2 Access and safety accreditation

1.2.1 A national approach to rail safety will facilitate open access and competition on the interstate rail network by ensuring safety is not a barrier to the entry of third party operators.

1.3 Aim.

1.3.1 It is the aim of Accreditation Authorities when implementing and administering the Rail Safety Intergovernmental Agreement, the Australian Standard and relevant State legislation to do so in a manner which is efficient, seamless, well coordinated between jurisdictions and minimises administrative requirements for clients.

1.3.2 An essential element in achieving these outcomes is a 'one stop shop' approach to interstate safety accreditation, whereby the client has only to approach one Accreditation Authority and that Authority will facilitate mutual recognition and liaison with Accreditation Authorities in the jurisdictions the applicant wishes to operate in.

1.4 The Railway safety management standard

1.4.1 The Rail Safety Intergovernmental Agreement refers to an "Australian Rail Safety Standard". This is "the principles and standards prepared, approved and published by the Standards Association of Australia in relation to rail safety".

1.4.2 The Australian Standard AS 4292 on *Railway safety management* is being prepared by the Standards Australia Committee on Railway Safety in response to a request by the former Railways of Australia Committee, and with the support from railway regulators. A uniform set of safety standards will simplify the development of safety management systems. The Standard is also intended to facilitate the interfacing of owners and operators for any railway, and to facilitate the safety accreditation of railway industry participants.

1.4.3 The set of standards, AS 4292, comprises:

- Part 1: General and interstate requirements
- Part 2: Track, civil and electrical infrastructure
- Part 3: Rolling stock
- Part 4: Signalling and telecommunications systems and equipment
- Part 5: Operational systems
- Part 6: Interface with other transport modes

1.4.4 AS 4292.1 *Railway safety management – Part 1: General and interstate requirements* was published on 15 June 1995. Parts 2-6 should be published by the end of 1996.

1.5 Definitions

1.5.1 The definitions to be applied to the Notes on Administration are the same as those set out in Clause 1 of the Agreement, and where appropriate supplemented by the definitions in the Standard in Clause 1.5 of *Part 1: General and interstate requirements*.

1.5.2 While the definitions in the Agreement and the Standard are the primary sources for interpretation of these Notes, it should be recognised that accreditation is based on Commonwealth or State Acts and the definitions contained in these Acts do not always correspond precisely to those in the Agreement or the Standard.

1.5.3 These differences in terminology reflect variations in Commonwealth or State legislation drafting practices and the fact that some rail safety legislation preceded the Agreement and the Standard. It is envisaged that when the Agreement, Standard and accreditation legislation are reviewed there will be a move to harmonise definitions wherever possible.

PART 2 - MUTUAL RECOGNITION OF ACCREDITED SAFETY MANAGEMENT SYSTEMS

2.1 Application

2.1.1 As a general principle, applicants for interstate safety accreditation should seek accreditation from the Accreditation Authority responsible for the jurisdiction in which the majority of their operations occur. However, it is recognised that some applicants may seek accreditation in a particular jurisdiction for commercial or managerial reasons, eg. applicants may seek accreditation in the jurisdiction where their head office is located.

2.1.2 The form of the application used by an applicant seeking interstate safety accreditation initially will be that required by the Accreditation Authority in whose jurisdiction the application is lodged. It is intended that a common application form will be developed for interstate safety accreditation conforming to AS 4292.1.

2.1.3 Any application for interstate rail safety accreditation will include, as a minimum, the scope of the proposed operations, the accreditations the applicant already holds and any information relating to accreditations which may have been withheld or withdrawn.

2.1.4 Any Accreditation Authority receiving an application for interstate safety accreditation (referred to as the Facilitating Authority) will be responsible for facilitating accreditation and liaison with the jurisdictions where the applicant is seeking interstate safety accreditation.

2.1.5 Upon application by an owner or operator for rail safety accreditation for interstate operations, the Facilitating Authority shall advise the other Accreditation Authorities in whose jurisdictions the railway operations are proposed to take place and request comment on the application. It would be expected that this notification would occur within 10 working days of the formal lodgment of an application.

2.1.6 The items listed below incorporate the 'common essential requirements' listed in Clause 2.3.2 of Australian Standard 4292.1. The advice from the Facilitating Authority will cover these items as appropriate.

(a) The proposed owner's or operator's address, telephone and fax numbers;
(b) Whether the proposed owner or operator has negotiated or is negotiating a commercial agreement in the Accrediting Authority's jurisdiction;
(c) Safety accreditations held by the applicant and advice on any accreditations withheld or withdrawn;
(d) Routes to be used, including parts of terminals and marshalling complexes;
(e) Rolling stock - locomotives, passenger cars, freight vehicles, and other vehicles to be used including:
    (i) Vehicle and load dimensions including clearances
    (ii) Roadworthiness of vehicle
    (iii) Permissible speed limit of vehicles
    (iv) Size, shape, gauge and gauge tolerance of wheels
    (v) Limits on wheel flange thickness, shape and wheel defects
    (vi) Coupling types, height and maintenance limits

(vii) Braking system, including train performance parameters
(viii) Vehicle equipment
(ix) Vehicle maintenance standards and procedures
(x) Vehicle recognition including bogie types
(xi) Electrical resistance (impedance) between wheel to rail contact faces on the same axle
(xii) Electrical compatibility between traction systems, and signalling and communication systems
(xiii) Vigilance controls;

(f) Track and civil infrastructure – on the proposed route including
(i) Structure clearances
(ii) Track gauge and tolerance
(iii) Capacity of track and civil infrastructure
(iv) Track and crossing work geometry;

(g) Electric traction infrastructure - where appropriate this would include
(i) Fault protection
(ii) Power supply parameters
(iii) Electrical clearances and approach distances
(iv) Spatial location of conductors
(v) Safety switching and isolation procedures
(vi) Earthing and bonding;

(h) Train control safe working, signalling and telecommunications systems.
Effective 2-way communication between train crew and the worker controlling trains shall be a prerequisite of any application;

(i) Operations - including
(i) Availability and suitability of route
(ii) Train performance
(iii) Indication of track speed limits
(iv) Axle loads
(v) Securing of loads
(vi) Emergency procedures
(vii) Crew competence

2.1.7 In addition to the items listed under 'common essential requirements' attention is drawn to Clause 7.3.1 in the Standard.

General requirements. All owners and operators involved in interstate system operation shall prepare, implement and maintain the necessary systems which ensure for railway safety in accordance with this Standard.

The general requirements cover
- Management policy and structure
- Risk and incident management
- Personnel management
- Goods services procurement
- Engineering and operational systems safety

INTERGOVERNMENTAL AGREEMENT

ON RAIL SAFETY

NOTES OF ADMINISTRATION

PART 2- INTERGOVERNMENTAL AGREEMENT ON RAIL SAFETY PANEL OF INVESTIGATORS

PART 3 - INVESTIGATIONS

3.1 Purpose

3.1.1 An investigation of an interstate rail accident or major incident shall be conducted in accordance with Clause 8 of the Intergovernmental Agreement on Rail Safety (IGA) and the Australian Standard on *Railway safety management*, AS 4292.

3.2 Type of accidents to be investigated

3.2.1 Accidents or serious incidents subject to interstate investigation are those specified in relevant Commonwealth and State legislation, including legislation which under Clause 4 of the Intergovernmental Agreement provides for the application of the Australian Standard and any additional requirements notified under Clause 7 of the Agreement. This includes accidents and serious incidents specified in Category A of Appendix C of AS 4292.1, which are:

(a) Death - death as a direct result of the incident;
(b) Serious personal injury - admission to hospital;
(c) Running line derailment - any derailment occurring in the normal forward movement of a train on a running line after it has fully completed its marshalling and pre-journey examination;
(d) Collision - a collision between trains, other rolling stock vehicles or obstructions on main running lines;
(e) Level crossing accident - a collision involving a train with either a road vehicle or a person at a level crossing, including a pedestrian crossing.

3.3 Request for an independent investigation

3.3.1 An accredited railway owner or operator or a Party to the Intergovernmental Agreement may request an independent investigator to investigate an interstate accident or incident under Subclause 8(1) of the IGA.

3.3.2 A State or Territory may request an independent investigation into an intrastate accident or incident which occurs in its jurisdiction under Subclause 8(7) of the IGA. The State or Territory may or may not be a Party to the Agreement.

3.3.3 A request for an independent investigator shall be made to the responsible rail investigator only in the jurisdiction in which the accident or incident occurred. (IGA Subclause 8(2))

3.4 Appointment of investigators

3.4.1 The decision to appoint an independent investigator shall be made by the responsible rail investigation body of the jurisdiction in which the accident or incident occurs. This investigator may replace another investigation. (IGA Subclause 8(3))

3.4.2 The railway owners, operators and any other parties involved in the accident or incident should agree to the investigator(s) proposed by the jurisdiction in which the accident or incident occurs. However, if no agreement can be reached, the jurisdiction in which the accident or incident occurs shall appoint the investigator(s). (IGA Subclause 8(5))

3.4.3 As a matter of principle investigators nominated by their Government should be made available by their employers for the duration of an investigation.

3.5 Panel of investigators

3.5.1 Investigators for the Panel of Investigators under IGA Subclause 5(4) are nominated by their Government. Persons on the Panel of Investigators are listed at Attachment 3A.

3.5.2 The Panel of Investigators shall be regularly reviewed and updated by the representatives of Accreditation Authorities referred to at 2.5.1.

3.6 Legal powers and protection for investigators

3.6.1 Investigators should have the legal powers and protections provided by the jurisdiction in which the accident or incident occurs. (IGA Subclause 6(3))

3.6.2 Indemnity from legal action by the railways and any other parties involved in the accident or incident should be obtained for the investigator(s) before the investigation starts.

3.6.3 The specific legal powers and protections for investigators afforded by each jurisdiction are outlined in Attachment 3B to 6 for each State.

3.7 Investigators terms and conditions of service

3.7.1 Investigators appointed under Clause 6 of the IGA shall be entitled to the terms and conditions of service provided in their normal place of employment, if employed by a railway or government agency. Otherwise the terms and conditions of service shall be agreed between the investigator and the jurisdiction in which the accident or incident occurred. (IGA Subclause 6(2))

3.8 Competency and training of investigators

3.8.1 As investigators are nominated by their Government, they are deemed to be competent due to their experience, skills and training. It is recognised that while investigators are experts in certain areas of an inquiry they are not expected to be an expert in every area. Investigators are encouraged to gain additional training in and knowledge of investigative procedures and skills and to have a broad understanding of areas they do not have expertise in.

3.9 Inquiry terms of reference

3.9.1 Emphasis should be given to determining all the factors contributing to an accident or incident.

3.9.2 A generic terms of reference could be:

(a) Clearly establish the factual circumstances leading to the accident or incident and immediately following the accident or incident.

(b) Identify the direct cause or causes of the incident and any other contributing factors including any human factors or underlying matters contributing to the accident or incident.

ATTACHMENT 3A

INTERGOVERNMENTAL AGREEMENT ON RAIL SAFETY
PANEL OF INVESTIGATORS

(23 July 1996)

COMMONWEALTH

<u>Psychologists</u>

Initial Contact		
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Deputy Director (Policy)		
Mr Alan Hobbs		
Ms Majella McDonald		
Mr Graham Edkins		
Mr Michael Walker		
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PO Box 967		
CIVIC SQUARE ACT 2608		

<u>Civil Engineer</u>

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KESWICK SA 5035		

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Executive Director		
Mr Grant Holliday	Ph:	(02) 268 2914
Manager, Traction and Rollingstock		
Mr Bill Fowler	Ph:	(02) 268 2874
Manager, Track and Structures		
Mr Bob Glew	Ph:	(02) 268 2205
Manager, Rail Operations		
Transport Safety Bureau	Fax:	(02) 268 2925
NSW Department of Transport		
227 Elizabeth Street		
SYDNEY NSW 2000		

QUEENSLAND

Initial Contact

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Principal Advisor		Fax:	(07) 3253 4333

Rail Safety Accreditation Unit
Land Transport & Safety Division
Queensland Transport
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230 Brunswick Street
FORTITUDE VALLEY QLD 4006

Civil Infrastructure

Mr Tim McSweeney	Group Manager Infrastructure, Rockhampton
Mr Clive Plunkett	Manager Infrastructure (South), Brisbane
Mr Jim Paul	Permanent Way Engineer, Brisbane

Rolling stock

Mr Clive Sheppard	Group Manager Rollingstock, Citytrain, Brisbane
Mr Barry Payne	Brake Engineer, Brisbane
Mr Don Sherman	Vehicle and Track Engineer, Brisbane

Operations

Mr Kevin Wright	Manager Train Operations, Citytrain, Brisbane
Mr John Graham	Manager Train Operations (South), Brisbane

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SOUTH AUSTRALIA

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Group Manager Technical Services		Mobile:	0419 810 442
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MELBOURNE VIC 3000		

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<u>Signals</u>

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<u>Track</u>

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HAWTHORN EAST VIC 3123		

Mr Douglas Lloyd	Ph:	(03) 9560 0672
5 Mannering Drive	Fax:	(03) 9619 4703
GLEN WAVERLEY VIC 3150		

Synergy Contact
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Director, Public Transport Safety Directorate | Fax: (03) 9619 4855
Department of Infrastructure
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MELBOURNE VIC 3000

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Initial Contact
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Manager Safe Working | Fax: (09) 326 2070

Mr John Bizzeta
Principal Engineer Operations

Westrail
Westrail Centre
West Parade
EAST PERTH WA 6004

INTERGOVERNMENTAL AGREEMENT

ON RAIL SAFETY

NOTES OF ADMINISTRATION

PART 5 COMPLIANCE INSPECTIONS

PART 4 - INFORMATION EXCHANGE

4.1 Purpose

4.1.1 The purpose of the information exchange system is to facilitate informed decision making, enhance the safety performance of the railway industry and enhance regulatory effectiveness.

4.2 Rail accident and incident data to be exchanged

4.2.1 The rail accident and incident data to be collected and aggregated by each Accreditation Authority reflects Category A incidents and selected Category B incidents in Australian Standard AS 4292.1 Appendix C.

4.2.2 The rail accident and incident categories to be used are:

(a) Running line derailment

(b) Collision with
- (i) passenger train
- (ii) freight train
- (iii) livestock
- (iv) obstruction
- (v) pedestrian
- (vi) other

(c) Level crossing accident/incident
- (i) road vehicle involved
- (ii) pedestrian involved
- (iii) level crossing equipment failure
- (iv) other

(d) Signal passed at stop
- (i) completely missed
- (ii) driver misjudged
- (iii) restored as train approached
- (iv) other

(e) Signal irregularities
- (i) wrong side signal failure
- (ii) other

(f) Slip, trip or fall
- (i) from train
- (ii) between platform and train
- (iii) on train
- (iv) on track
- (v) on platform/concourse
- (vi) on escalator/lift
- (vii) on stairs

(viii) form structure
(ix) caught in train doors
(x) other

(g) Yard derailment

(h) Loading irregularity
(i) door open
(ii) out of gauge
(iii) load shift
(iv) other

(i) Dangerous goods
(i) on train
(ii) off train

(j) Safeworking irregularities/breach
(i) system failure
(ii) human failure

(k) Infrastructure irregularity
(i) broken rail
(ii) buckled track
(iii) spread track
(iv) other

(l) Rolling stock irregularity
(i) train parting
(ii) broken wheel/axle
(iii) hot boxes/collapsed bearings
(iv) faulty passenger train door
(v) braking system
(vi) other

(m) Electrical irregularity
(i) overhead traction supply
(ii) other

(n) Fire or explosion

(o) Vandalism
(i) train struck by missile
(ii) obstruction
(iii) on train
(iv) on platform
(v) other

(p) Assault
(i) on train
(ii) on platform
(iii) other

ATTACHMENT 4C

PERFORMANCE NORMALISING FACTORS - INCLUDING INJURY SEVERITY, PROPERTY DAMAGE AND ADDITIONAL INFORMATION

4C1 Performance Normalisers

Reported every calendar month by total rate, best rate and worst rate for the following.

4C1.1 Per Million Passenger Journeys
4C1.2 Per Million Population
4C1.3 Per Thousand Employees

1.3.1 Breakdown by Grade	Grades to include are driver, drivers assistant, guard, shunting staff, examiner, station staff, on board staff, office staff, technical staff, infrastructure staff, workshop staff, helpline centre staff.

4C1.4 Per Million Train Kilometres
1.4.1 By Passenger Train and Freight Train
4C1.5 Per Thousand Kilometres of Track

4C2 Injury Severity

4C2.1 Passenger	A person who is joining, on, or alighting from a train (includes employees not travelling in the course of their duties).
2.1.1 Fatal	A loss of life as a direct result of an accident.*
2.1.2 Serious Personal Injury	Injury that results in admission to hospital.
4C2.2 Employee	A person other than a contractor or volunteer who does work for or at the direction of a railway owner or operator.
2.1 Fatal	
2.2 Serious Personal Injury	
4C2.3 Contractor	A person (and any employee of that person) who has a contract or service to carry out work for a railway owner or operator.
2.3.1 Fatal	
2.3.2 Serious Personal Injury	
4C2.4 Volunteer	A person who works for a railway owner or operator or works on railway property without financial reward.
2.4.1 Fatal	
2.4.2 Serious Personal Injury	

402.5 Trespasser — A person unlawfully on railway property.

2.5.1 Fatal
2.5.2 Serious Personal Injury

402.6 Public/Other — Persons not included in any other category.

2.6.1 Fatal
2.6.2 Serious Personal Injury

** Idea of life occurs within 12 months of accident and the Accreditation Authority is advised statistics will be adjusted.

403 Property Damage

403.1 Nature of Event
403.2 Estimated Value

3.2.1	Not assessed		
3.2.2	Low	-	$1 - $10 000
3.2.3	Moderate	-	$10 001 - $100 000
3.2.4	High	-	$100 001 - $1 000 000
3.2.5	Extreme	-	$1 000 001 plus

404 Additional Information

404.1 Alcohol and Drugs — Any alcohol, drug or medication test which has been called for to ascertain whether these substances contributed to an accident or incident.

4.1.1 Positive — 0.02 and above.
4.1.2 Negative — Below 0.02.

404.2 Type of Train

4.2.1 Passenger — A train designed and used for carrying passengers.

4.2.1 (a) Suburban — Any train which is restricted to travel within a metropolitan region.

4.2.1 (b) Non suburban — Any train which travels long distances and across regions.

4.2.2 Freight — A train used for conveying freight, such as coal and minerals, grain, fuel, livestock and containers.

4.2.3 Other — Anything which does not fit one of the above categories - provide description.

404.3 Type of Traction — The type of power unit hauling a train.

4.3.1 Electric
4.3.2 Diesel
4.3.3 Steam
4.3.4 Other

APPENDIX J

INTERGOVERNMENTAL AGREEMENT

ON RAIL SAFETY

NOTES OF ADMINISTRATION

PART 5 COMPLIANCE INSPECTIONS

PART 5 - COMPLIANCE INSPECTIONS

5.1 Purpose

5.1.1 Compliance inspections will be undertaken or arranged by each Accreditation Authority to ensure that railway owners and operators meet their safety obligations to conform with their accreditation requirements.

5.2 Types of compliance inspections

5.2.1 Two basic types of compliance inspections exist.

(a) Pre-accreditation - This is the initial phase where the level of competency and expertise of the applicant is evaluated and verified. This is a requirement on initial application and forms part of the accreditation process. Inspections will be completed before accreditation is granted.

(b) Post-accreditation - The Accreditation Authority will establish a regime to ensure that systems are complied with as detailed in the accreditation. In general compliance inspections will be undertaken at least once every 12 months. However, the frequency will be determined in the first instance as part of the accreditation process, and then as subsequent circumstances require.

5.3 Safety culture

5.3.1 It is recognised that the Accreditation Authority has a role in changing and developing the safety culture of railway organisations.

5.4 Minimum acceptable standards

5.4.1 All Accreditation Authorities will develop guidelines for establishing minimum standards. It is not intended that Accreditation Authorities determine minimum standards but rather that they provide guidelines. Uniform guidelines for interstate operators will be developed by December 1995 and made available to the rail industry.

5.5 Core rail groups

5.5.1 There are four core groups of rail safety -

- Track and other civil infrastructure
- Rollingstock
- Signalling and Communications
- Operations

5.5.2 Generally, with the exception of rolling stock and some aspects of operations, compliance inspections will be undertaken within each state by or on behalf of the State Accreditation Authority.

RISK MANAGEMENT TRAINING

MODULE 1 CONCEPTS AND PRACTICE

ALARA

ALARA Risk Management Services Pty Ltd

Risk Analysis

Concepts & Practice

An introduction to risk analysis, with case studies

Prepared for the Public Transport Corporation

Course presenter - Mark Andrew

Course format & objectives

- Course format
  - 2 days
  - Knowledge transfer
  - Team skills development
  - Structured informality
  - Opinion-focused with legal information
  - Organisation wide
- Course objectives
  - At the end of the course participants' should be able to
    - » Describe risk analysis and loss control concepts
    - » Identify organisational factors that influence the success of risk analysis
    - » Understand a generic risk analysis methodology
    - » Apply specific tools to analyse risks
    - » Assess risk analysis requirements and support sources

Risk Analysis
Concepts and Practice

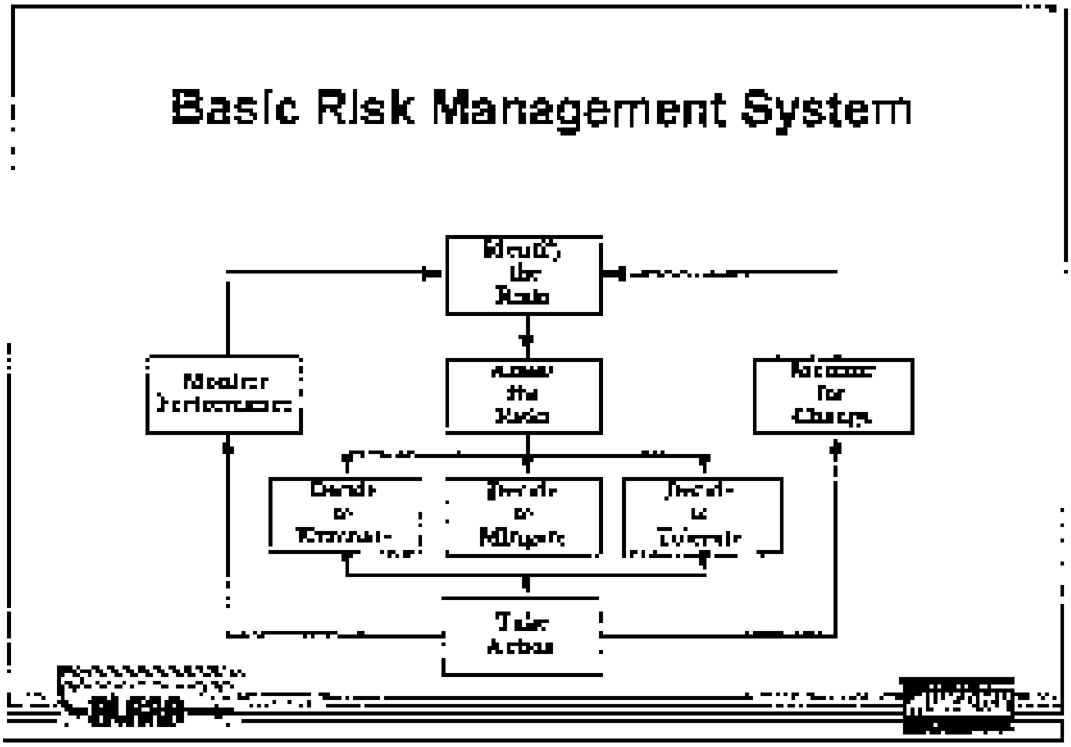
- Concepts of risk & loss control; costs & benefits
- Organisational factors
- The link with quality
- Generic methodology
- Specific tools
- Case study
- Risk "products"; implementation

This course is aimed at providing an overview of risk analysis and related concepts.

At the end of the course participants should be able to describe basic risk concepts including loss control principles, understand organisational factors relevant to risk analysis, and use risk analysis tools within an accepted risk analysis methodology.

Case studies will provide an opportunity to practice the techniques illustrated throughout the course.

Course Notes - Risk Analysis, Concepts & Practice



An organisational view of risk is vital to successfully integrating risk analysis into a Risk Management system.

Typically, organisations will attempt isolated risk analyses on high priority issues to "test" the approach.

This prioritised approach to risk analysis is the beginning of a program of risk analyses. The steps in developing a system can be described as follows:

- Isolated risk analyses
- Prioritisation of corporate risk issues
- Development of a corporate method and risk measurement scheme
- Roll-out of the Risk Management system components through skill and knowledge development

Barriers to successful implementation include the incorrect or inappropriate application of analysis tools, and inadequate follow-up on actions.

Part 1
Concepts

- Course overview
- Loss & Loss Costing
- Risk Management System
- Risk Analysis
- Risk definition
- Team-based qualitative ranking
- Safety Precedence Sequence
- The System Approach

Part 2
Organisational factors & quality

- Basic Risk Management System
- The Classic Model for Analysis
- Real Time Management
- Quality systems & risk analysis
- Common definitions
- Probability
- The aims of risk assessment
- Plant Regulations

Part 3
Generic methodology

- Energy concepts
- Energy sources
- Workplace Risk Assesment & Control (WRAC)
- Risk Ranking Method
- Control selection
- Barrier classifications

Part 4
Tools

- Overview of tools
- Flow charting
- Failure Mode & Effect Analysis
- HAZOP

RISK MANAGEMENT TRAINING

MODULE 2 – ADVANCED RISK ANALYSIS

TOOLS, APPLICATIONS AND SYSTEMS

ALARA Risk Management Services Pty Ltd

Advanced Risk Analysis

Tools, Application & Systems

Prepared for the Public Transport Corporation

Course presenter - Mark Andrew

Advanced Risk Analysis

- Tools and techniques - Day 1
  - Fundamentals of Probability
  - Fault Tree Analysis (FTA) & Failure Modes
  - Human Error as a Failure Mode
- Application - Day 2 and half of day 3
  - Team-based risk exercises
  - Case study review - homework
- Systems - Half of day 3
  - AS/NZS 4360
  - Acceptability?
  - Systems Planning & Implementation

The objective of this course is to build on the basics of risk analysis by introducing new tools and techniques, and encouraging practice.

Specifically, participants will be taken through:

•Additional tools, such as Fault Trees and additional Human Error schemes

•Real based case studies, to be used as practical exercises

•Systems implementation issues, including the requirements for Risk Management Systems as defined by AS/NZS 4360

RISK MANAGEMENT TRAINING

MODULE 5 - SAFETY SYSTEM ACCIDENT INVESTIGATION

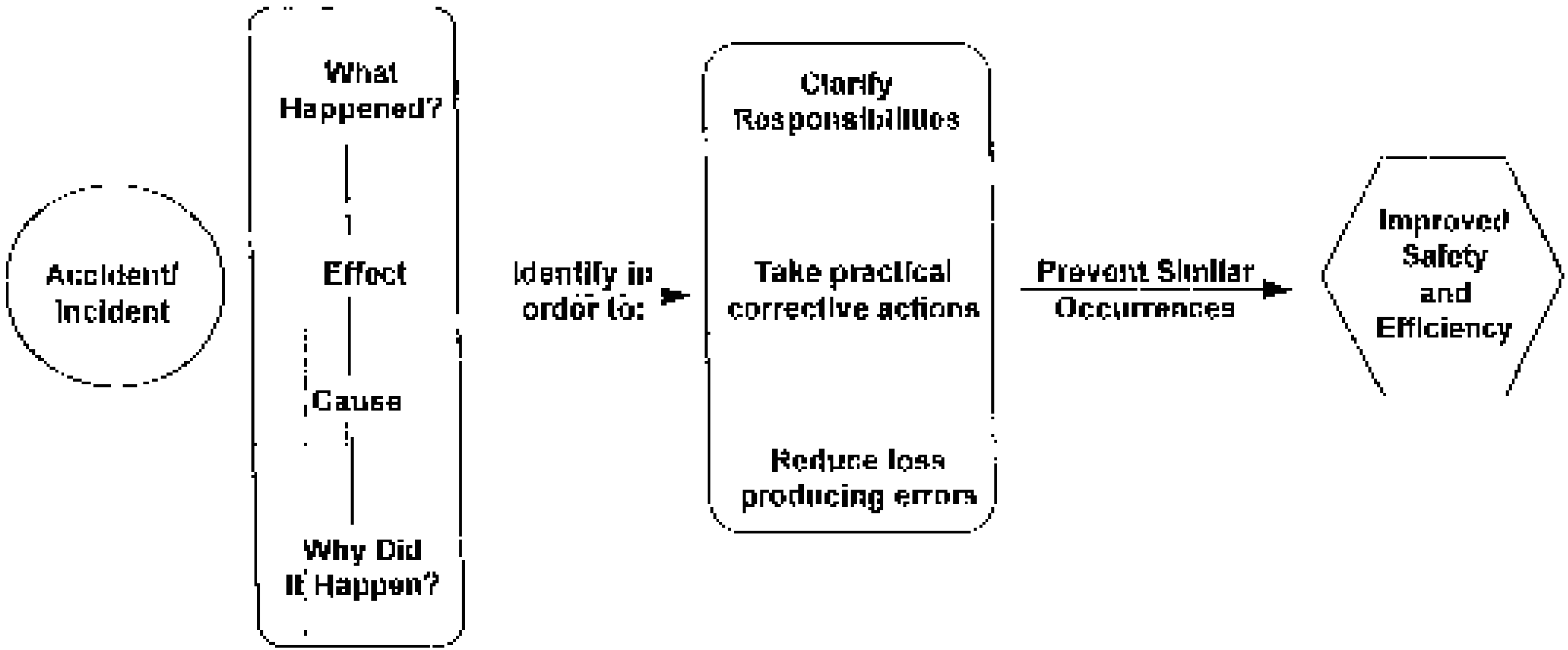
System Safety Accident Investigation Skills Workshop

- 1. Accident Investigation Overview
- 2. Accident Investigation Technology
- 3. Analytical Techniques for Serious Accident Investigation
- 4. Events and Conditions Charting
- 5. Human Error Analysis
- 6. Accident Investigation "Logic" and Change Analysis
- 7. Investigation Management

MINERISK

The Purposes of Accident Investigation

Primary Purpose



The Purpose of Accident Investigation

- Secondary Purposes:
  - Determine the nature and extent of the event.
  - Assist in improving Policies, Procedures and Standards.
  - Dispel any mystery.
  - Demonstrate management's concern about accident prevention and safety.

MINERISK

Why This Workshop?

- Accidents happen and should not be ignored.
- There is a lot to be learned from investigating accidents.
- Investigation is not a random or haphazard process.
- Investigation includes identification of the basic facts, and analysis of various causes or factors.
- This process of investigation can be systematic.
- Systematic accident investigation provides the best results in terms of gaining knowledge - and therefore provides safer operating practice.
- This systematic approach is called System Safety Accident Investigation (SSAI).
- It can be learned and the workshop will demonstrate the team-based approach to SSAI.

MINERISK

QUALITY ASSURANCE

INTERNAL AUDITOR TRAINING

SMART QUALITY ASSOCIATES PTY LTD

Public Transport Corporation

QUALITY ASSURANCE INTERNAL AUDITOR TRAINING

(PART OF A MANDATORY REQUIREMENT OF QUALITY MANAGEMENT SYSTEMS)

AS/NZS ISO 9002: 1994

PRESENTED BY

SMART QUALITY ASSOCIATES PTY LTD

Continuous Quality Improvements In

Total Quality Management

SYSTEM
MANAGEMENT
AUDITING
REVIEW
TRAINING

"Quality is everybody's business."

TABLE OF CONTENTS

SMART QUALITY ASSOCIATES PTY LTD

3

1. FOREWORD/COURSE OBJECTIVES

1.1 QUALITY ASSURANCE IN INDUSTRY

In 1987 the Australian Government tabled the results of Dr. Kevin Foley's report recognised that Quality Assurance "offers more scope for reducing cost and enhancing competitiveness and profitability than any other management controls". Then in May 1992 Ms Simone Swenson and Mr. Alan Walker from the commonwealth launched the Q/A policy which supported the Foley report.

As a result, many sectors of industry were encouraged by Governments, both Local, Federal, and major purchasers to introduce Quality Assurance Systems. Companies concerned have realised significant benefit in terms of profitability and market share.

Introduction of Quality Management Systems involves the need to audit the system to ensure continuing effectiveness. Auditing requires a degree of expertise, towards which this course is intended to contribute.

1.2 COURSE OBJECTIVES, UNDERSTANDING AND PARTICIPATION

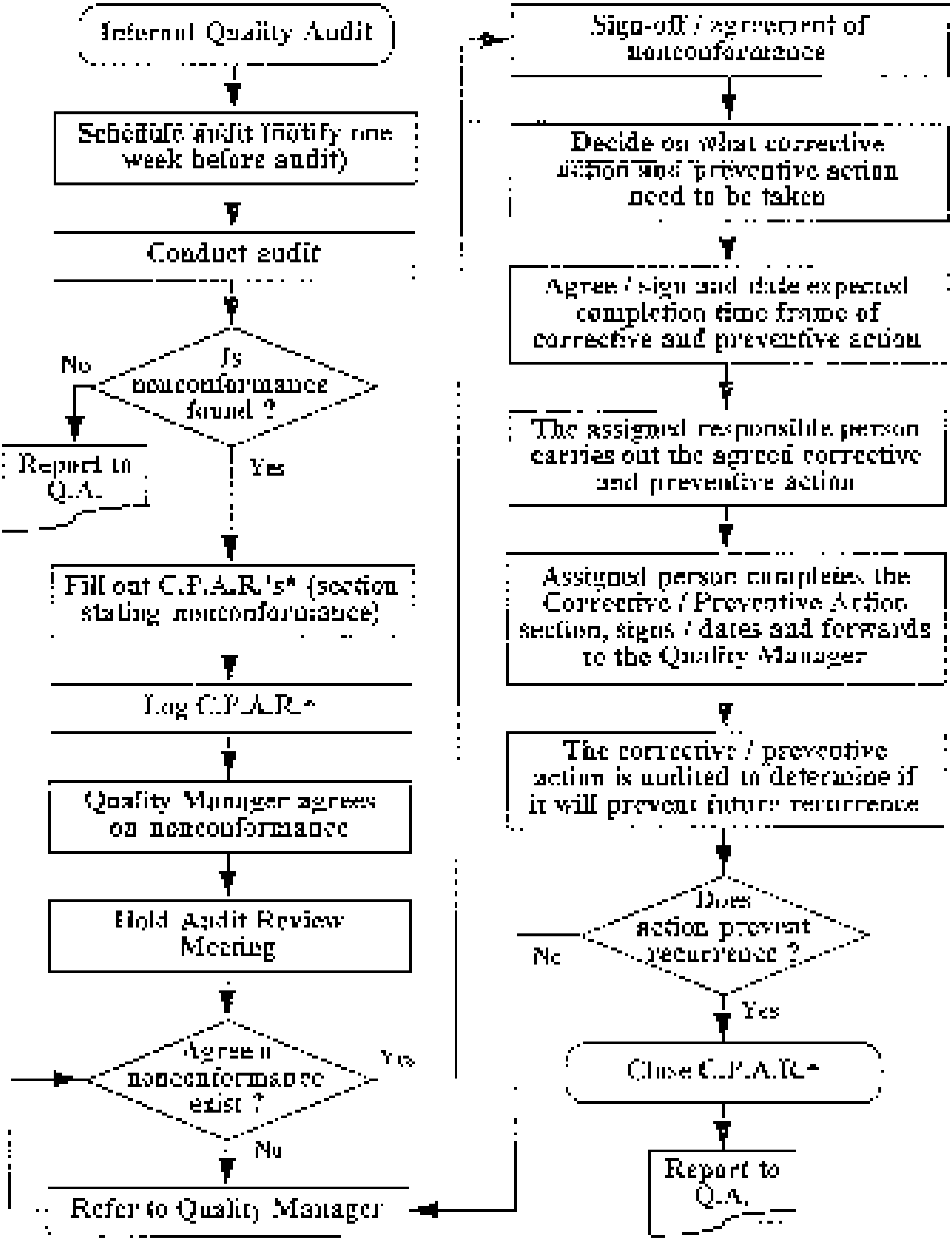
This course is designed to:

- provide a basic understanding of Internal Quality Systems auditing;
- explain different types of audit and their application;
- explain and demonstrate the techniques involved in planning, executing, reporting and follow-up of audits;
- give delegates sufficient basic training to be able to participate in Quality Management Systems Internal auditing.

Role play, lectures, workshops and supplementary video material are the methods used to achieve the course objectives.

INTERNAL QUALITY AUDIT (DETAILED)

QP 4.17 - A.S. / I.S.O. 9001 and A.S. / I.S.O. 9002



FLOWCHART 2

* C.P.A.R. - Corrective and Preventive Action Request

SEPTEMBER 1994

SMART QUALITY ASSOCIATES PTY LTD

TOTAL QUALITY MANAGEMENT IN PERSPECTIVE